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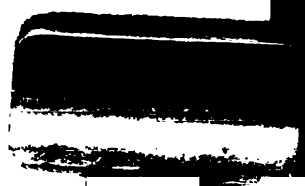
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GEOLOGICAL SURVEY OF CANADA

SECTION OF MINES

MINERAL RESOURCES OF CANADA

BULLETIN No. 1

PLATINUM



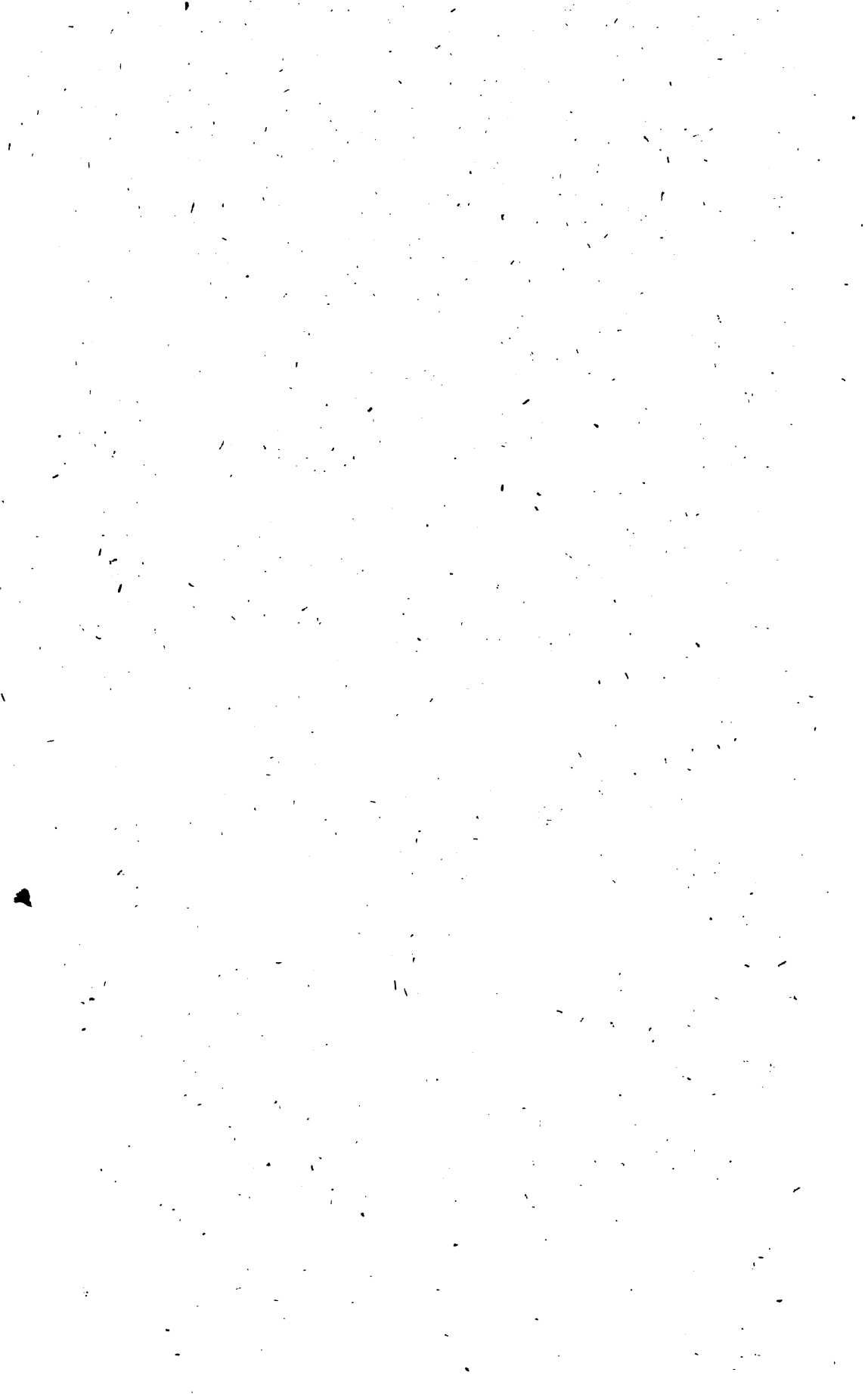
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GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, M.D., D.Sc. (CANTAB.), LL.D., F.R.S.

SECTION OF MINES

MINERAL RESOURCES OF CANADA

BULLETIN No. 1

PLATINUM

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GEOLOGICAL SURVEY OF CANADA,
OTTAWA, March 27, 1903.

ROBERT BELL, M.D., LL.D., F.R.S.,
Acting Deputy Head and Director.

SIR,—I beg herewith to submit a pamphlet dealing with platinum.

It represents a reprint with additions of the article with that title forming a portion of the Annual Report of the Section for 1901 (Part S, Vol. XIV) Annual Report of the Geological Survey Department, The material has been collected and prepared by Mr. Theo. Denis, B.Sc.

Pursuant to a policy suggested some years ago and now carried out with your permission, this pamphlet is intended to be the first of a series giving, in condensed and popular form, information regarding the mineral resources and possibilities of the country, together with any data regarding similar occurrences in other countries which may be of use to prospectors and operators in Canada.

I am, Sir,
Your obedient servant,

ELFRIC DREW INGALL.

PLATINUM

PLATINUM.

So far the production of this metal is altogether derived from the Production, placer working on the Similkameen river district of British Columbia. As will be seen on inspection of the figures in Table 1 below, the yield has been generally falling off for some years past. The amount is now insignificant.

TABLE 1.

PLATINUM.

ANNUAL PRODUCTION OF PLATINUM.

Calendar Year.	Value.
1887.....	\$ 5,600
1888.....	6,000
1889.....	3,500
1890.....	4,500
1891.....	10,000
1892.....	3,500
1893.....	1,800
1894.....	950
1895.....	3,800
1896.....	750
1897.....	1,600
1898.....	1,500
1899.....	825
1900.....	Nil
1901.....	457
1902.....	190

PLATINUM. As articles of platinum are not manufactured in Canada, there is no home market for the crude metal and the imports, as shown in Table 2, represent only the finished articles.

Imports.

TABLE 2.
PLATINUM.
IMPORTS OF PLATINUM.

Fiscal Year.	Value.
1883.....	\$ 113
1884.....	576
1885.....	792
1886.....	1,154
1887.....	1,422
1888.....	13,475
1889.....	3,167
1890.....	5,215
1891.....	4,055
1892.....	1,952
1893.....	14,062
1894.....	7,151
1895.....	3,937
1896.....	6,185
1897.....	9,031
1898.....	9,781
1899.....	9,671
1900.....	57,910
1901*.....	20,263

*Platinum wire and platinum in bars, strips, sheets or plates: platinum retorts, pans, condensers, tubing and pipe, imported by manufacturers of sulphuric acid for use in their works. Duty free.

It is to be hoped that the increasing demand for this valuable metal may stimulate prospecting and lead to the discovery of other workable deposits. With this in view Mr. Theo. Denis, B. Sc., of the Staff of the Mines Section has prepared the following article on the subject, giving in condensed form, information inaccessible to the ordinary reader on account of its being scattered throughout a number of technical publications. Descriptive matter relating to the mode of occurrence and methods of working deposits in other countries has been included as suggestive of points likely to be of use to the prospector and miner in Canada.

OCCURRENCES OF PLATINUM IN CANADA.

Occurrences. Although the first reference to the occurrence of platinum in Canada was made as early as 1852, by Dr. T. Sterry Hunt, yet, the production

so far, as may be seen by the table given above, has been very small PLATINUM. and moreover the figures show great irregularity from year to year. Occurrences. This is due to the fact that in Canada this metal is obtained as a by-product only, mainly in the working of some auriferous placers in British Columbia, and in many cases the black platiniferous sand which is held back in the riffles of the sluiceboxes, is overlooked and thrown away owing to the ignorance, on the part of the miners, of its value or of the mode of further treatment. Even as late as 1899, the Provincial Mineralogist for British Columbia in his report for the year says that 'It appears that many of the placer miners do not know its value and throw it away as so much black sand.' This may have been due to the fact that until a few years ago the demand for platinum was somewhat limited and the market price accordingly comparatively low; but at present, owing to its extended uses, the price has risen, so that it now rivals that of gold, the market price for ingot platinum during 1901, ranging from \$18.00 to \$22.00 per ounce.

Platinum was first noticed in Canada in 1852, as mentioned in the Geology of Canada of 1863. It was found on Rivière-du-Loup, province of Quebec, near its junction with the Chaudière, in the course of washing sand for gold. Associated with this native platinum were plates of a hard steel gray metal resembling iridosmine. There is also another record of platinum having been found under similar conditions in Rivière des Plantes, Beauce county, in the province of Quebec. The quantity was very small and these finds possess at present only a historical interest. If, however, placer mining should be more vigorously prosecuted in this region it is not impossible that platinum might become a valuable by-product of the operation.

The recorded Canadian production of platinum comes from British Columbia, where the metal is obtained mainly in connection with the working of the auriferous deposits of the Similkameen and Tulameen rivers.

It is rather difficult to ascertain when platinum was first discovered in British Columbia. In his 'Mines and Minerals of Economic value of British Columbia,' (Geol. Surv. Rep. 76-77), the late Dr. G. M. Dawson mentioned finds of platinum on the Similkameen, Tranquille and Fraser rivers. But as some of those placers were first worked as far back as 1858 it is very probable that the black platiniferous sand must have come to the notice of gold miners a good many years before.

However, the first record of its having been saved is found in the report of the gold commissioner of the Similkameen division for 1886 in which he says: 'Mixed with the gold found in this district, and pos-

PLATINUM. sessed of a greater specific gravity, is a whitish metal which at first
Occurrences. was thrown away under the impression that it was worthless. For
considerable time no definite idea could be procured as to its value. Mr. Jenson, of Granite City, who forwarded a sample to a cousin of his at Manchester, England, for analysis has kindly supplied me with the desired information. The metal is principally platinum, containing small quantities of iridium, osmium, and palladium. Its value depends on the percentage of platinum, which varies in quantity and may be considered as worth about \$2.50 per ounce. The selling price at Granite City was 50 cents per ounce; so the purchasers will reap a handsome return for their investment.' The following year he estimates the production to have reached some 2,000 ounces, which commanded from \$2.60 to \$3.00 per ounce.

Platinum has been found in many places in British Columbia in association with gold, in alluvial deposits, an annotated list of localities being given below, but the region of the Similkameen and Tulameen rivers (north fork of Similkameen) is by far the most important.

The origin of the platinum found in the placers of the district, has not been definitely ascertained; Dr. Dawson in his report on the Mineral Wealth of British Columbia expresses himself as follows: The metal (platinum) occurs in notable quantity in the region of the upper Similkameen and Tulameen, in minute scales where the gold is "fine" but increasing in coarseness to small pellets and nuggets in places where "coarse" gold is found. Coarse grains and pellets of platinum have so far been found only on Granite, Cedar and Slate creeks, all entering the Tulameen on the south side. In certain claims in these creeks, the platinum has been found to equal half the weight of gold obtained Though above referred to as platinum, the metal so named is alloyed with several other metals of the same class, of which osmiridium is the most abundant. Specimens of the native platinum from Granite creek have been subjected to careful examination and analysis by Dr. Hoffmann, who states that the material "having the composition of the ore here in question would, at the present time, be worth, from \$2.90 to \$3.65 per ounce troy in the English market." Osmiridium is employed, on account of its great hardness, for tipping the nibs of gold pens. "For this purpose it is necessary that it should be in the form of natural grains, and these are very carefully selected, the requirements being that they should be solid, compact and the proper size and shape." This was not however found to be the case with the grains present in the platinum from Granite creek.

Platinum has very rarely been discovered in veins or otherwise in its original matrix. In Russia, whence the greatest quantities are obtained, it is almost always found as in the cases above cited in association with gold-bearing alluvions, although it has been noted in a few places with little or no accompanying gold. It appears to be derived from rocks consisting of serpentine and peridotite with talcose and chloritic schists and chromite. While there is a notable abundance of greenish chloritic and hornblendic schists and diabase rocks (resulting from the metamorphism of old volcanic rocks) in the Tulameen and upper Similkameen region of British Columbia, and chromite and magnetite are here found in the workings in association with the platinum and gold, no peridotite or serpentine is actually known to occur. The circumstances in connection with the occurrence of the 'coarse' platinum appear to point to the vicinity of an important mass of intrusive diorite as its point of origin. A great part of the associated magnetite is certainly derived from veins in this rock and it seems not improbable that the platinum, and possibly also a great part of the gold of this district, may occur in scattered grains in this intrusive mass. Very little vein-stuff occurs in the gravels with which the platinum and gold of this region are associated. (Geol. Surv. Rep. 87-88 part R.)

Occurrences.

Later investigations however have led to a modification of the views expressed as above by Dr. Dawson in 1888.

The following statement by Mr. R. W. Brock was published in the Summary Report of the Geological Survey of Canada for 1901 p. 67 : "It (platinum) has been found in the Similkameen district and is known to occur at many points in the western United States. When found in place it has generally been confined to serpentine, and when found in sands it is usually in the neighborhood of serpentine. Consequently streams draining masses of serpentine in particular should be prospected for platinum. Serpentine, as above noted, occurs at a number of points in the district examined this summer, as on July creek, Hardy mountain and Central Camp. It also occurs on the range east of the Cascade."

A very interesting investigation on a sample of platinum from Granite creek was conducted by Dr. G. C. Hoffmann of the Geological Survey. The original sample weighed 18.266 grams, of which .372 consisted of rock matter, pyrite and gold. The sample was submitted to magnetic separation, and divided into two parts, which on analysis gave the following results :

PLATINUM.		Non Magnetic.	Magnetic.
Occurrences.	Weight	11.115 grams.	6.779 grams.
	Platinum	69.19 %.	78.43 %.
	Palladium.....	0.26	0.09
	Rhodium.	3.10	1.70
	Iridium.....	1.21	1.04
	Osmium.....	...	....
	Copper.....	3.09	3.89
	Iron.....	7.87	9.78
	Osmiridium.....	14.62	3.77
	Gangue.....	1.95	1.27
		100.29	99.97

This determination shows, therefore, a proportion of 72.07% of platinum in the 17.894 grams of material analyzed. For the purpose of comparison, platinum contents of samples of platinum bearing material from different parts of the world are given: The analyses are by Messrs. Deville and Debray; Oregon, 51.45 %; Australia, 61.40; California, 85.50; Choco, Columbia, 86.20; Nischne Tagilsk, Urals, 76.40.

The following is a list of Canadian localities at which the occurrence of platinum has been noticed. With the exception of that at Sudbury, Ont., all the finds have been made in the alluvial deposits, usually while working for gold.

Rivière du Loup, and Rivière des Plantes, province of Quebec. (See note above.)

Sudbury, Ontario.—This occurrence is one of the very few in the world where platinum is found "in situ."—In this case the metal is found in combination with arsenic and associated with the nickeliferous pyrrhotite deposits. The arsenical platinum mineral was named sperrylite by H. A. Wells who described it, and found it to consist on analysis of: Platinum 52.57 per cent; Rhodium 0.72; Antimony 0.50; Arsenic 40.98; Iron 0.07; Tin oxide 4.62.

At Sudbury the ore bodies consist of chalcopyrite and nickeliferous pyrrhotite, which are primarily worked for their nickel and copper contents, and yield a large proportion of the world's supply of nickel. The ore undergoes a first treatment at the mines, where it is smelted, the low grade matte first made containing approximately 15 per cent of nickel and about the same proportion of copper and the Bessemerized matte from 35 to 40 p.c. of nickel. This is shipped to the refinery in New

Jersey where it is finally treated. According to a reliable authority ^{PLATINUM.} this matte holds 1.25 oz. of the platinum metals per ton of nickel ^{Occurrences.} contents of the matte, and of this some 80 per cent is extracted. In 1900 the matte shipped from Sudbury, contained approximately 4,594 tons of nickel. The platinum metals would therefore, on that basis have amounted to 5,742 oz. This however is not included in the table of production, as returns of platinum from this source are not sent in to the Mines Section.

North Saskatchewan, N.W.T. Native platinum has been found in association with gold on the bars in the North Saskatchewan river, in the neighborhood of Edmonton, district of Alberta. A sample of the material from this locality received from Mr. Pearce consisted of exceedingly minute rounded and flattened grains of native platinum, the largest not exceeding one fourth of a millimeter in diameter, with intermixed, equally minute scales of native gold. (Geol. Surv. Rep. 90-91 part R).

Yukon river and tributaries, Y. T. Platinum was reported to have been found in small quantities along all or nearly all tributaries of the Yukon in association with river-bar gold (Geol. Surv. Rep. 87-88). but these reports have not been verified by fuller investigation and it is still uncertain whether this metal has been discovered or not on the Yukon river.

It has been reported lately that comparatively large quantities of platinum were bought at low prices from placer miners in the Yukon, who were ignorant of its value, and sold again at a large profit in Vancouver.

Teslin (Hootalinqua river), Y.T.—A discovery of platiniferous sand was made in 1898, at the mouth of the Hootalinqua river and on Thirty Mile (Lewis) river. A company was said to have been subsequently organized to work these alluvions for the gold and platinum, by means of dredges.

Upper Similkameen and Tulameen rivers, British Columbia, especially on Granite, Cedar and Slate Creeks. (See note above.)

Tranquille river, B. C. This river which flows into Kamloops lake, was worked before 1862 by gold miners; later the work was taken up by Chinamen. Gold is found for a distance of eight miles from the mouth. The metal is scaly and mixed with it are particles of platinum, similar in shape and size to those of gold.

(Geol. Surv. Rep. 1877-1878 part B.)

PLATINUM. *Fraser river, British Columbia.* Found in small quantities in fine scales, with gold, particularly at a place ten miles below Lillooet. (Geol. Surv. Rep. 87-88).

A sample of crude platinum sand from washings in the Fraser river gave the following result :—

Base metals.....	6.48%.
Platinum group.....	81.30
Osmiridium.....	12.20

Rock creek, Camp McKinney, Yale district, B.C. A sample of heavy black sand taken from the riffles of sluice-boxes at Camp McKinney, Rock creek, a tributary of Kettle river which contained in addition to gold a large proportion of native platinum, gave on analysis the following results :

Native platinum.....	44.7
Gold	1.8
Magnetite.....	47.4
Quartzose sand.....	6.1

The platinum was in the form of exceedingly minute to moderately coarse irregularly shaped grains, the largest of which measured four millimeters in diameter. (Geol. Surv. Rep. 92-93).

North Thompson and Clearwater rivers, B.C. The discovery of platinum in the North Thompson and Clearwater rivers has created some interest, as its existence was not formerly suspected. It is found associated with the alluvial gold but the extent and condition of the finds are not yet fully determined. (Rep. Minister of Mines, B.C., 1900).

SOURCES OF THE WORLD'S SUPPLY. OCCURRENCE AND TREATMENT.

Although platinum is known to occur in situ in several places, it is in such small quantities, that nowhere are these occurrences worked for the metal. These deposits have therefore at present no direct economic value although their study may eventually throw light on the origin of this metal which so far is not well understood. Platinum has been found in place (in contradistinction to alluvial deposits) in the following countries, a short description being given in each case.

Columbia.—In Columbia the platinum deposits may be divided into two main classes, the more recent alluvial deposits and the "caliche" beds. These last are deposits which consist of clay, sand

and boulders indiscriminately mixed and which show no stratification. PLATINUM
Those deposits are probably of glacial origin, and are the oldest plati- Occurrences.
niferous deposits of El Choco. They frequently contain diorite boulders, and it seems possible that the platinum will eventually be found disseminated in this rock. The true gravel deposits of El Choco are newer than the "caliche" beds and in part derived from them. The largest deposits of the kind are situated along the Tamana, Iro, and San Juan rivers. These are from 6 to 20 feet deep and have been extensively worked by the natives. (Min. Ind. Vol. I.) Although the "caliche" beds cannot be said to contain platinum in situ, yet the occurrence differs from the ordinary alluvial deposits. The annual production of Columbia has varied for the last few years between 10,000 and 12,000 oz.

New South Wales.—In New South Wales platinum is said to have been detected in felsite and granite at Broken Hill. It is, of course, very sparsely disseminated. It has also been found in small quantities in washings for gold at several places, and since 1894 there is a production recorded, which is very irregular and varies between 500 and 2,000 ozs. annually.

Brazil.—In Brazil platinum is found associated with gold in quartz lenses intercalated in gneiss and schists.

United States.—As to the United States, Mr. David T. Day in a paper read before the American Institute of Mining Engineers in February 1900 makes the following statement:

"Messrs. William E. Hidden and J. H. Pratt have found sperrylite-platinum arsenide in placers at several points in the Cowee valley of North Carolina. The conditions favour the belief that the source of this mineral is a ledge of impure rhodonite and biotite, containing much disseminated iron sulphides, conditions much like those at Sudbury, Canada.

"There have been unsubstantiated reports of the occurrence of platinum in place in certain localities of the Catskills in New York, in granite near Philadelphia, and again near Port Deposit, Maryland."

As to alluvion deposits he says:

"Platinum has been found at many places on the Pacific beach, from as far south as San Bernardino county, northward to the mouth of the Columbia. Indefinite reports have been made of its occurrence further north on the Washington beach; but its amount is certainly not great. The principal beaches where platinum has been reported, beginning at the south, are: Santa Barbara, Lampoc, the beaches of San Luis,

PLATINUM. Obispo county ; Santa Cruz, and occasionally between Santa Cruz and the Golden Gate. In accordance with Blake's statement, the richest beaches are further north, in Humboldt and Del Norte Counties. The beach mines of Gold Bluff north of Arcata, Big Lagoon, Stone Lagoon, Little River, Crescent City, Cal., and Gold Beach and Port Orford, in Curry county Oregon, have all yielded platinum in commercially appreciable quantities. Still further north, platinum is found at Yaquina beach, Oregon, but the sands there are poor."

Occurrences.

Russia.—The metal is found in the Ural mountains sparsely disseminated in peridotite and serpentine masses. The platiniferous alluvial deposits are also characterized by the presence of boulders of olivinite and serpentine, which both contain chromite. Thus the source may be said to have been placed, the matrix being beyond doubt the serpentinized olivinite. It is even reported that a streak or zone of this rock some six feet wide in a massive olivinite, was actually worked for some time for its contents of platinum, but at a depth of about 35 feet it was no longer workable. It does not seem certain that platinum has been found in the perfectly fresh igneous rock which had not yet undergone serpentinization, hence there is a possibility that the same agencies that brought about the conversion of the olivine into serpentine also introduced the platinum into the rock. (Min. Ind. Vol. VI. Abstract.)

Over 90 per cent of the world's production of platinum is derived from the placer deposits of the Urals in Russia. The whole of the platinum producing portion of these mountains is contained within a length of 100 miles along the 60° meridian E. of Greenwich, between latitudes 57.30° and 59° and is all included within the government of Perm. Within this area there are two chief districts, Goroblagodatsk in the north and Nishni Tagilek in the south. The platinum placers occupy the valley bottoms of a number of streamlets and their branches, the alluvions of the larger streams being rarely rich enough for working. In the Goroblagodatsk district, which lies wholly on the Asiatic side of the Urals, the placers are found on the river system of the Ias and its tributaries which, in its turn, discharges into the Tournai. The total length of the Ias and its affluents is about 60 miles.

In the southern district the main producing area lies on the European side of the Ural watershed in the river systems of the Vissine and the Martian. On these 18 placers are being worked. On the Asiatic side there are three fields of operation on the Chornaia and its tributary, the Chonge.

The platiniferous alluvion is very variable in thickness and in richness, but always shallow, the placers being undoubtedly of quaternary age. These placers carry gold in addition to the platinum, but these metals did not occur together in primary deposits, and their presence together is due to the fact that the stream which formed the alluvial deposit, received the product of disintegration of rocks containing gold and of rocks containing platinum, the source of gold being traceable to quartz veins or to rocks of an acid type, whereas the platinum is derived from basic rocks.

PLATINUM.

Occurrences.

The thicknesses of the respective layers of overburden and platiniferous alluvion are also recorded, and are as follows: Overburden average 16 feet (maximum 63 feet, minimum $2\frac{1}{2}$ feet), pay gravel, average $3\frac{1}{2}$ feet (maximum 6 feet, minimum 1 foot). The average richness of these pay-sands being at present about 2 dwt., crude, to the ton. The yield of platinum to the ton of gravel washed was at first much higher, but has decreased considerably within recent years. According to private records the sands of the Gorablagodatsk district in 1870 yielded 1 oz per ton, in 1882 this fell to 9 dwt., in 1886 to $4\frac{1}{2}$ dwt. and in 1895 it was $1\frac{1}{2}$ dwt. In the Nishni Tagilsk district, the same decrease is noticeable. This progressive impoverishment is due to the fact that at first only the small shallow and rich placers at the headwaters of the smaller streams were worked; and as these were exhausted, gradually poorer and poorer deposits further down stream had to be attacked, till now there is nothing left but the more extensive low grade placers in the large valleys and the tailings of earlier washings.

Crude platinum, as obtained by washing of the gravels, is in the form of fine particles, grains and scales, of about the size of the finest gunpowder; its colour varying from light to very dark grey. Nuggets are occasionally met with, the largest found in the Gorablagodatsk district was $72\frac{1}{2}$ ozs, and in the Nishni Tagilsk 310 ozs.

Methods of Working.—The method of working the placer gravels is almost everywhere identical. There are two different labour systems in force in all the alluvial workings of Russia. The men are either day labourers receiving regular wages, or they are 'starateli' or free labourers. These latter are what the Cornish miner would call 'tributers'; they are allowed to work certain portions, in some cases the whole of a placer, practically as they please, and are in turn bound to sell the platinum they produce, to the individual or company owning the placer, at a fixed price, which is usually less than half its value. These men are said to be able to work gravels too poor to be worked by day wages.

PLATINUM.

Occurrences.

The method of working adopted by the 'starateli' is simple in the extreme; they establish a short sluice-box or 'tom' in some position where they can run a stream of water into the head of the box. One of the most usual types of sluice used in the Urals consists of a box about 2 feet wide, into which the gravel is dropped, and through which a current of water is run. The stream of gravel and water is carried into the sluice proper, which consists of a box, some two feet wide by 30 feet long, inclined at a low angle (about 5°). The far end is opened and terminates in a chute under which a cart can stand to receive the boulders and large pebbles. On the bottom of this sluice, at intervals of about 7 feet, there are three openings which are 9 inches by two feet (the width of the box). These openings are grated with bars of iron set $\frac{1}{2}$ inch apart, and through these, practically all the finer sand and water drop, whereas the larger stones continue on to the chute. Beneath each grating runs a transverse box to receive the sand and water which drop through the gratings. These boxes are also inclined at a low angle and deliver into a trough which lies at a steeper angle; this trough carries the sands, which are now considered worthless, into a settling box, whereas the water runs off into the ditch. The sands are shovelled from the settling box into carts for removal. The bottoms of the main sluice of the transverse boxes, and of part of the trough are covered with riffles and coarse matting, forming interstices for catching the heavy sand. As will be seen, this sluice is really the hydraulic miners sluice, undercurrent and grizzly in miniature. In some places this sluice is combined with a simple machine for disintegrating clayey gravels. When the work is done on an extended scale either by a large company of starateli or by mine owners, washing machines are built and the pay gravels are brought to them in small carts drawn by one horse. The machines are usually driven by steam. One type of washing machine consists of a cylindrical tub, the bottom of which is a circular cast iron pan 15 inches deep, pierced with $\frac{5}{8}$ inch holes; around the top of the pan runs an annular cast iron pipe, perforated so as to allow water in small jets to play into the pan. In the centre is a vertical shaft carrying a six-armed spider, from each of the arms of which hang a couple of iron bars that almost touch the bottom of the pan. The shaft is revolved at about 25 revolutions per minute, and the gravel is fed in continuously. The large stones which remain after the disintegration are removed from time to time, while the sands and clayey matter suspended in water pass through the perforated bottom and fall upon a sloping board covered with stout sheet iron which discharges into a large box, the front of which is closed by a strong wooden grating kept always padlocked

while the machine is in operation. The bottom of the box is inclined PLATINUM. at an angle of about 15°. It is eight feet wide and the bottom is Occurrences. covered by stout bass mats, which are held in place by stout pieces of wood about 3 inches deep, which are kept in their places by wedges, and act as riffles. The sands drop through the grating into a transverse shallow trough, then over a table some 18 feet long and furnished with wooden riffles and one or two more troughs. At the bottom of the table the sands drop into a wooden chute which is at such a height above the ground that these sands can be carried by the stream of water to a low dump, some 100 yards away from the machine.

It is evident that any coarse pieces of platinum or nuggets which are the most liable to be stolen, will be retained in the padlocked section of the table, while most of the finer platinum sands are also caught in the mats; the lower table is said to catch very little, but this however is no proof that the tailings are clean, for all the arrangements now in use are obviously unsuitable for catching flour platinum. The machine referred to above can treat about 100 tons in 12 hours, the volume of water required being from 5 to 10 times that of the gravel. The clean-up of the different appliances usually takes place every 12 hours at 5 p.m. and 5 a.m. The sands resulting from the clean-up are then further concentrated in another very simple sluice, consisting of an upper portion in the shape of a box lined with sheet iron and a lower portion which consists of a narrow box about 15 feet long which is laid with well washed peats forming shallow riffles. The sands are thrown in small quantities into the box and then worked about with a hoe or a narrow shovel in a carefully regulated current of water; the bulk of the platinum is retained in the box, the rest being caught in the riffles and most of the lighter material is carried away. The rich concentrates thus obtained, seem to consist of crude platinum, chromite and a few of the heavier minerals. They are finally cleaned on a small flat table or wash-board. This consists of two tables separated by a drop of two inches. Above the upper one is a small box which delivers a regular shallow stream of water over the whole breadth of the table, the force of the current being just sufficient to move the average-size particles of platinum. The breadth of the board is about 3 feet. The concentrated sands from the sluice are thrown on the upper table and are continually pushed upward against the current by means of a little wooden hoe. On this table the concentration is finished; the sands are worked with the hoe until fairly clean and are then allowed to be carried by the stream of water to the lower table, where the washing is completed. The clean platinum sands are then collected off both tables and stirred up with suffi-

PLATINUM. oient mercury to dissolve any gold that may be present. The platinum
 Occurrences. left behind is now ready for the market. In its crude state it usually
 contains from 75 to 85 per cent of pure metal. It is then ready to be
 sold to the refineries. The bulk of the produce of Russia is exported
 in the crude state.

In *Colombia*, which is the platinum producer next in importance to
 Russia, the metal is also recovered by very simple methods. The
 greater proportion is obtained from the working of the "caliche"
 beds which are usually ground-slucied. River bars and beds are worked
 in even a more primitive way; women diving for the black sand and
 washing it in pans.

Since the foregoing notes were compiled and printed in the Report
 of the Section of Mines for 1901, a bulletin on 'Geological Relations
 and distribution of platinum and associated metals,' by Prof. J. F.
 Kemp, of Columbia University, New York, has been published by the
 United States Geological Survey and treats the subject very exhaust-
 ively. Owing to the importance which the question of the supply of
 platinum is assuming, it is thought that abstracts of some parts of this
 bulletin could very appropriately be appended to this article and
 special attention drawn to the bearing which some of the observations
 mentioned in the bulletin may have on certain rocks in Canada which
 might be found on careful search to be platiniferous. Some results
 have also been given of the analyses of serpentine rocks collected by
 R. W. Brock in British Columbia and assayed by Donald Locke,
 both of the Geological Survey of Canada.

Source and
 associated
 minerals.

In connection with platinum deposits, many observers have
 endeavored to trace back to the rock *in situ* the source of the metal
 found in placers. Minerals associated with the nuggets in the alluvial
 deposits are therefore important to consider, especially those minerals
 which are found to actually form part of the nuggets and which are
 therefore derived from the same source, such as the following, viz:
 chromite, olivine, serpentine, pyroxene, mica and gold. As to minerals
 which are present merely as components of the gravels they offer less
 interest; they are, as a rule, minerals of high specific gravity, and on
 panning, one may expect to find among them gold, silver, copper,
 metals of the platinum group, chromite, magnetite, garnet, &c.

Chromite.—Chromite is by far the commonest of foreign minerals
 found attached to the nuggets. The two minerals seem to have crys-
 talized simultaneously, for they are, as a rule, intergrown so that

either of them may be found including the other. In British Columbia, nuggets have been observed to have a crumbly appearance, as if the grains of chromite were bound together by the platinum, and it may be surmised that such nuggets could not have travelled very far. Platinum nuggets with chromite attached to them have been reported from Columbia, Russia, British Columbia, and also one from Plattsburg, in New York State. This last is discussed further on, as it is of special interest. It is of interest to note that chromite suggests a basic igneous rock as the source of chromitiferous platinum nuggets.

Source and associated minerals.

Olivine.—In some British Columbia nuggets, olivine acts as an envelope to the core of platinum. This would point to a peridotite as the mother rock of these platinum nuggets. Russian nuggets have been found with serpentine attached, which certainly was derived from olivine.

Pyroxene.—In British Columbia, some nuggets have been found with attached crystals of augite, near occurrences of pyroxenite, suggesting this rock as the probable source.

The Russian platinum mines of Tagilsk are located along rivers which rise in the mountains of Soloviev, and this suggested the advisability of searching in the mountains for the original source. The country rock is a fine grained variety of peridotite consisting of colourless olivine, which predominates, bound together by serpentine in which is disseminated chromic iron; the serpentine being probably an alteration of the olivine. At a place where an excavation had been made, probably in search of platinum, a sort of pocket, a foot or so in diameter, was observed in the country rock. It consisted principally of angular grains of chromic iron, and in the interstices were serpentine and a little dolomite acting as a cement. An assay of this rock gave 0.0107 per cent of platinum or about 3 ounces per ton.

Platinum has been observed to be a constituent of some copper ores, in tetrahedrite and bournonite, at Val du Drac in France, at Guadalucaque in Spain, in the latter case in a vein; and at the Rambler mine in Wyoming; in this last occurrence it is found as sperrylite, (the arsenide of platinum,) in covellite. Two assays, by Baker & Co., of the matte in car load lots produced from the Rambler mine furnace gave the following results:

	I.	II.
Gold.....	0.45	0.16 oz. per ton.
Silver.....	7.40	3.80 "
Platinum....	1.05	0.74 "
Palladium.....	3.15	1.80 "

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The mines of Commern and Mechernick in Germany, where nodules of galena and cerrusite occur in Triassic sandstone, yield silver which contains some platinum. These deposits also hold copper carbonate in small quantities, so it is uncertain whether the platinum is associated with the lead or the copper.

Discoveries of platinum in traces in veins, more especially associated with copper show that the metal is not necessarily confined to olivine rocks, or even to igneous rocks. However, in all cases of the discovery of the metal *in situ*, the amount is commercially very small.

The finds of platinum in gravels in the Chaudiere River district, province of Quebec, Canada, have been mentioned in another part of this article. In connection with this, however, it is very interesting to note that some years ago a platinum nugget was found in glacial drift near Plattsburg, N.Y. This nugget weighed 104 grains, of which 46 p. c. was metallic platinum and 54 p. c. chromite. As it was found in the drift it had undoubtedly been brought from the north, very probably from the great areas of serpentine which occur in the province of Quebec, parts of which are worked for chromite.

There seems to be no doubt that this nugget has been derived from this source, although no platinum in place has yet been reported from the serpentine region. The presence of the metal in the sands of the Chaudiere seems to confirm the surmise. These two occurrences were not probably derived from the same source *in situ*; for the 'belt' of igneous rocks in which areas of serpentine occur, extends from the boundary of Vermont to the Shickshock mountains in Gaspé, and in connection with the serpentines at many points, are found deposits of chromite more or less extensive. This therefore suggests a wide field awaiting careful search for the source of the platinum.

A great many of the serpentine occurrences of this belt are described in the reports of Dr. R. W. Ella, on the geology of the Eastern Townships, and these may be consulted with advantage by any one interested in this subject. They are Vol. II., 1886, part J; Vol. III., 1887-88, part K; Vol. VII., 1894, part J; Vol. XI., 1898, part J, of the Reports of the Geological Survey of Canada.

In his report on the copper ores of Ontario (Report of Ontario Bureau of Mines, Vol. IX) Dr. A. P. Coleman mentions that on lot 15, Con. IV. of McConkey Tp., Parry Sound, to the north of Lake Cariboo, there are large areas of rusty diabase. At one point where an excavation some six feet deep, has been made, the loosened rocks show some iron and copper pyrites, and pyrrhotite. The sulphides

show in seams and stringers, but no well defined vein is exposed. It **PLATINUM.**
 is said that Mr. Hays of Toronto found on assaying some of the **Source and associated minerals.**
 selected ore 1.55 p. c. copper, 1.20 p. c. nickel and 1 oz. 3 dwt. 8 grs.
 of platinum per ton. However, a sample from this occurrence collected by Dr. Coleman gave some nickel and gold, but neither copper nor platinum.

The British Columbia sources of platinum, have so far been the most productive in North America and these have been the subject of special personal study on the part of Professor Kemp.

He states that the platinum bearing area of chief interest in this region is in the valley of Slate creek and along the Tulameen river below Eagle creek. A great dyke of peridotite which is flanked on both sides by areas of pyroxenite crosses the Tulameen river at its junction with Eagle creek. As far as could be ascertained this peridotite is of the dunite variety and contains no chief mineral constituents other than olivine, chromite and some secondary serpentine. The pyroxenite is a coarsely crystalline rock made up mainly of common augite and it is of later date than the peridotite which it penetrates in places in tongues and dykes. Both olivine and pyroxene have been observed adhering to the nuggets found in the Tulameen, and as the peridotite contains no pyroxene it is therefore probable that the platinum has been derived from both the peridotite and the pyroxenite.

In the endeavour to trace the platinum back to its original location, tests were made of serpentine veins rich in chromite and of dykes of pyroxenite in the peridotite. Assays of the serpentine gave amounts of platinum varying from a trace to nearly 2 ounces per ton, whilst assays of specimens of the pyroxenite showing an abundance of magnetite and remote from the peridotite mass, gave only faint traces or nothing whatever. It can be concluded that the platinum is in extremely fine scales, and that large nuggets are rare and the weathering and concentration of enormous masses of rock must be surmised in order to account for the existence of the platinum-bearing gravels.

Platinum is said to have been found in former years at the mouth of Siwash creek, which enters the Tulameen, three miles above Eagle creek. The country-rock here is a granite in which are evidences of lines of dislocation. Along one of these where the granite is more or less decomposed and stained green by chlorite assays of this material gave traces of platinum. The granite of Siwash creek, which is highly acidic, consists of quartz, orthoclase, plagioclase, biotite and a little epidote. It could not be ascertained whether the platinum was

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confined to the lines of dislocation and brought there by solution or was an original constituent of the granite. However, the presence of platinum in connection with a highly acidic rock is interesting and important to note.

Platinum is said to have been observed in Brazil in quartz veins cutting a syenite gneiss.

In reviewing the different deposits and mineralogical associations of the platinum groups of metals, Prof. Kemp divides them into three types as follows.

I. Placers.—The source of the platinum of these deposits has been traced mostly to peridotite and also in cases to pyroxenites, gabbros, metamorphosed gabbros and syenite. They are the result of the weathering and natural concentration of enormous masses of rock by processes which must have been in action for very long periods of time.

II. Veins.—Occurrences of platinum in veins of different kinds have been recorded, as at Tilkerode, Harz Mts. Germany where it is found, in irregular lodes in diabase associated with quartz, selenides of lead and of mercury, dolomite and calcite; at Minas Geraes in Brazil, in quartz veins; at Santa Rosa, Colombia, and at Beresouk Russia. It has also been found associated with complex antimonial sulphides of copper and other metals (tetrahedrite and bournonite) at Gaudalcagual Spain and Val du Drac France, as well as in the Rambler mine, Wyoming, where it is found in the form of sperrylite in the covellite of the mine.

III. Disseminated in eruptive rocks.—In this case the platinum occurs in two forms as arsenide and in the native state. In the first mentioned condition it is associated with the copper-nickel ores of Sudbury, Canada, but appears in this case to be more closely connected with the chalcopyrite than with the nickeliferous pyrrhotite.

In the second form, that is in the native state, the platinum is found in basic eruptives, especially in peridotite, and it is intimately associated with chromite. Chromite occurs, as a rule, in connection with serpentines, all the deposits of any extent having so far been found in this rock, and hence appear to owe their existence to the process resulting in the alteration of the original olivine. On the other hand chromite has been discovered also in basic eruptives which are not at all altered to serpentine, so that it may also be looked upon as an original igneous mineral.

Mr. Kemp concludes his bulletin with a few suggestions of practical value which are given in full as follows:—

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minerals.

distributed throughout the vein matter; in some parts of the vein it may be present in commercial quantities, while in others it is absent. It has not been determined in what form the metal occurs, but it is probably held by the sulphides.

The district is one of considerable geological complexity. It has been the scene of numerous igneous intrusions extending from probably Palaeozoic to Tertiary times, and it has witnessed more than one mountain-building epoch.

Consequently the older rocks are much disturbed, sheared, fractured and altered. The oldest rocks are limestones, argillites and greenstones, of which the latter are the most extensive. A great part of the district is however composed of later intrusions. The limestones are sometimes pure, sometimes dolomitic. When comparatively unaltered they are dark and carbonaceous but are usually metamorphosed to a white marble. The argillites are often altered to schists and hornfels. These rocks have been intruded by the greenstone, probably an augite porphyrite, though it is usually much sheared and altered.

All the above rocks are cut by a coarse gray grano-diorite which sends dykes and apophyses into the older rocks. The greenstone on the "mother lode" is also cut by a basic gabbroidal rock which has some affinities to the non-basic monzonites. To the north is a large area of a still more recent hornblende granite, from which dykes are sent off into the older rocks. To the east is a large area of syenite of Pulaskite (alkali syenite) and monzonite habit. This rock is of Tertiary age. Numerous dykes of syenite porphyry, some of them no doubt from the alkali-syenite cut all the older rock.

The veins occur in the more disturbed districts where the porphyry dykes are most numerous. On the 'Contact' properties several quartz veins occur, but a little to the south are veins of zinc blende with a little galena.

Mr. Brock gives his reasons for making the suggestions as to the probable occurrence of platinum in British Columbia, published in the summary report of the Geological Survey for 1901 as follows:—

'The special reasons for suspecting its occurrence in West Kootenay and the Boundary Creek districts were the presence there of basic intrusive rocks, often altered to serpentine, rocks in which platinum has been most frequently found when in place and the rocks which are the source of the Similkameen platinum, and the fact that the chalcopryrite-pyrrhotite ore-bodies of these districts bear a very marked resemblance to the platinum-bearing copper-nickel deposits of Sudbury,

Ontario. The subsequent discovery of platinum in the copper ore of the Rambler mine, Wyoming, in the same form (sperrylite, the arsenide of platinum) as at Sudbury, further emphasized this probability. Source and associations.

'The basic igneous rocks in which platinum so often finds its home are not confined to southern British Columbia, but are known to occur all through the mountains at least to the Atlin district. The occurrences of ores possibly holding this metal are also similar over wide areas, so that the search for platinum must not be confined to the southern part of the Cordilleran belt in the province.*

In connection with the work recently prosecuted in the Sudbury district by Dr. A. E. Barlow for the Geological Survey Department samples of the mattes obtained were collected and assayed by Mr. Donald Locke of which we are enabled to give a resume below :—The full particulars will be found in Dr. Barlow's report which will shortly be issued.

One specimen of matte from the Mond Company's works yielded : copper, 37.37 per cent ; nickel, 41.88 per cent ; iron, 1.07 per cent ; cobalt, 0.33 per cent ; silver, 4.87 ozs. per ton ; gold, 0.066 oz. per ton, while the platinum group of minerals amounted to 0.4 oz. per ton.

In another sample of matte from the same place the gold and platinum minerals were not separated and amounted together to 0.60 oz. per ton.

In matte produced by the Orford company the results of the analyses were : copper, 34.95 per cent ; nickel, 40.37 per cent ; iron, 9.64 per cent ; cobalt, 0.78 per cent ; gold, 0.15 oz. per ton and the platinum group 0.5 oz. per ton.

Another sample from the same place was found to contain : silver, 2.50 ozs. per ton ; gold, 0.10 oz. per ton and the platinum group 0.44 oz. per ton.

In corroboration of the above may be mentioned the results given in a paper by L. P. Silver, on "Sulphide ore-bodies of the Sudbury region" Vol. V Can. Mining Institute, of an analysis of a sample of Bessemer matte which was found to contain : nickel and cobalt, 39.64 per cent ; copper, 42.75 per cent ; iron, 1.03 per cent ; sulphur, 14.05 per cent ; silver, 5.30 ozs. per ton ; gold, 0.75 oz. per ton ; platinum group, 0.50 oz. per ton.

* In the report of the Minister of Mines for British Columbia for 1902, reference is made to the occurrence of platinum accompanied by osmiridium in the black sands of the Quesnel River, Cariboo District. So far however it is not saved.

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GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, M.D., Sc.D. (CANTAB), LL.D., F.R.S.

MINERAL RESOURCES OF CANADA

COAL

*Reprint of Article in Annual Report of the Section of Mines for 1902,
Part S, Vol. XV.*



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GEOLOGICAL SURVEY OF CANADA,
OTTAWA, January 9, 1904.

To Dr. ROBERT BELL, L.L.D., F.R.S., &c.,
Acting Director.

SIR:—The following pamphlet dealing with the coal industry and coal-fields of Canada is reprinted from the Annual Report of the Mines Section for 1902, constituting Part S. Vol. XV, N.S., of the Annual Report of the Geological Survey Department.

Pursuant to a policy suggested some years ago and now carried out with your permission, this report is one of a series of similar bulletins intended to give in condensed and popular form, information regarding the mineral resources and possibilities of the country, together with any data regarding similar occurrences in other countries where such would seem to be of use to prospectors and operators in Canada.

I am, sir,
Your obedient servant,

ELFRIC DREW INGALL,
Mining Engineer in Charge.

MINES SECTION.

EXPLANATORY NOTE.

A number of special articles relating to the mineral industries and resources of Canada have appeared from time to time in the various reports of the Mines Section issued annually since 1897.

In these the aim has not been to write up the subject dealt with in great detail, but more particularly to meet the demand for precise descriptions serving to give the general public clear ideas of the important and salient features of given industries and mineral districts, together with references to the literature of the subject, so that anyone so desiring could pursue the subject in greater detail.

THE COAL MINING INDUSTRY OF CANADA.

The principal coal-bearing areas at present worked in Canada are the Nova Scotia coal-fields in rocks of Carboniferous age, the Cretaceous coals of Vancouver island and the more recently opened fields of the Crows Nest Pass B.C., also found in the Cretaceous rocks.* In Alberta, mining is being done in several different areas, Canmore, Lethbridge and Frank being the chief centres of activity. Small quantities of coal, likewise of Cretaceous age, are mined in the vicinity of Edmonton. Lignite of good quality is mined in the Souris river district, Assiniboia, and during the past two years small amounts have been mined in the Yukon district.

The total production of coal in 1902 was 7,193,142 tons (of 2,000 lbs.) valued at \$14,478,181, constituted as follows:—

	Tons.
Bituminous and lignite	7,176,592
Anthracite	16,550

The anthracite coal was mined in the Cascade Coal Basin, Alberta, the mine being situated at Anthracite on the main line of the Canadian Pacific Railway.

Compared with the previous year, the production of coal in Canada in 1902 shows an increase of 965,790 tons or over 15 per cent in quantity and \$2,472,616 or over 20 per cent in value.

The output is the largest that has yet been attained in Canada and is over twice the production of seven years ago.

Statistics of production are given in Tables 1, 2 and 3, following:—

TABLE 1.
COAL

Production.

PRODUCTION BY PROVINCES, 1900, 1901 and 1902.

Province.	1900.		1901.		1902.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Nova Scotia.....	3,623,536	\$ 8,088,250	4,158,068	\$ 6,496,982	5,161,316	\$ 9,216,636
British Columbia	1,623,180	4,347,804	1,660,515	4,447,809	1,534,902	4,111,344
North-west Territories including Yukon	351,950	839,375	391,139	1,008,917	478,129	1,110,521
New Brunswick.	10,000	15,000	17,630	51,857	18,795	39,680
Total	5,608,666	13,290,429	6,227,352	12,006,565	7,193,142	14,478,181

* A commencement has been made in coal mining in the Nicola district, B.C.

COAL.

Production.

TABLE 2.

COAL.

PRODUCTION. COMPARISON OF 1901 AND 1902.

Province.	INCREASE OR DECREASE.			
	Tons.	Per cent.	Value. \$	Per cent.
Nova Scotia	<i>i</i> 1,003,248	<i>i</i> 24·13	<i>i</i> 2,719,654	<i>i</i> 41·86
British Columbia.....	<i>d</i> 125,613	<i>d</i> 7·56	<i>d</i> 336,465	<i>d</i> 7·56
North-west Territories includ- ing Yukon.....	<i>i</i> 86,990	<i>i</i> 22·24	<i>i</i> 101,604	<i>i</i> 10·07
New Brunswick.....	<i>i</i> 1,165	<i>i</i> 6·61	<i>d</i> 12,177	<i>d</i> 23·49
Dominion.....	<i>i</i> 965,790	<i>i</i> 15·51	<i>i</i> 2,472,616	<i>i</i> 20·59

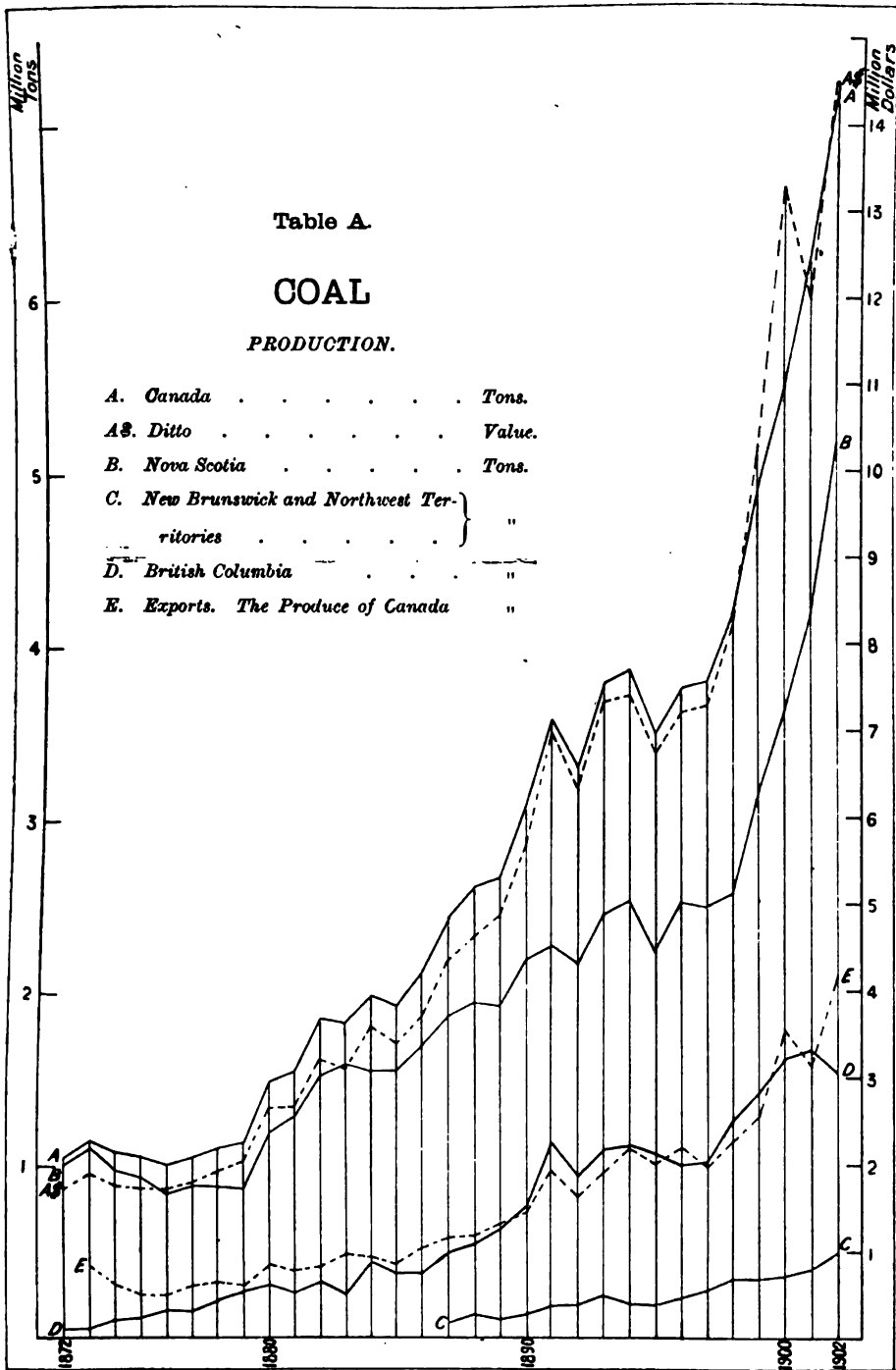
i Increase. *d* Decrease.

TABLE 3.

COAL.

ANNUAL PRODUCTION SHOWING THE INCREASE OR DECREASE EACH YEAR

Calendar Year.	Tons.	Value.	Average Value per Ton.	Increase (<i>i</i>) or Decrease (<i>d</i>) in Tonnage.	Incr. (<i>i</i>) or Decr. (<i>d</i>) per cent.
1886.....	2,116,653	\$3,739,840	\$1 77		
1887.....	2,429,330	4,388,206	1 81	<i>i</i> 312,677	<i>i</i> 14·8
1888.....	2,602,552	4,674,140	1 80	<i>i</i> 173,222	<i>i</i> 7·1
1889.....	2,658,303	4,894,287	1 84	<i>i</i> 55,751	<i>i</i> 2·1
1890.....	3,084,682	5,676,247	1 84	<i>i</i> 426,379	<i>i</i> 16·0
1891.....	3,577,749	7,019,425	1 96	<i>i</i> 493,067	<i>i</i> 16·0
1892.....	3,287,745	6,363,757	1 94	<i>d</i> 290,004	<i>d</i> 8·1
1893.....	3,783,499	7,359,080	1 95	<i>i</i> 495,754	<i>i</i> 15·1
1894.....	3,847,070	7,429,468	1 93	<i>i</i> 63,571	<i>i</i> 1·7
1895.....	3,478,344	6,739,153	1 94	<i>d</i> 368,726	<i>d</i> 9·6
1896.....	3,745,716	7,226,462	1 93	<i>i</i> 267,372	<i>i</i> 7·7
1897.....	3,786,107	7,303,597	1 93	<i>i</i> 40,391	<i>i</i> 1·1
1898.....	4,172,582	8,222,878	1 97	<i>i</i> 386,475	<i>i</i> 10·2
1899.....	4,925,061	10,283,497	2 09	<i>i</i> 752,469	<i>i</i> 18·0
1900.....	5,608,666	13,290,429	2 37	<i>i</i> 683,615	<i>i</i> 13·9
1901.....	6,227,352	12,005,565	1 93	<i>i</i> 618,686	<i>i</i> 11·04
1902.....	7,193,142	14,478,181	2 01	<i>i</i> 965,790	<i>i</i> 15·51



COAL.

The percentage of production to be credited to the several provinces at various periods since 1874 is shown in the following table :—

Province.	1874.	1880.	1890.	1898.	1899.	1900.	1901.	1902.
	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
Nova Scotia.....	91	79	71	61.4	63.9	64.6	66.8	71.8
British Columbia.....	8	20	25	30.3	29.0	28.9	25.7	21.3
Northwest Territories } New Brunswick.	.....	.....	4	8.3	7.1	6.5	6.5	6.9

Statistics of exports and imports are given in the following five tables :

TABLE 4.

COAL.

EXPORTS.

Exports.

CALENDAR YEAR.	PRODUCE OF CANADA.	NOT PRODUCE..	CALENDAR YEAR.	PRODUCE OF CANADA.	NOT PRODUCE.
	Tons.	Tons.		Tons.	Tons.
1873.....	420,683	5,403	1888.....	588,627	84,316
1874.....	310,988	12,859	1889.....	665,315	89,294
1875.....	250,348	14,026	1890.....	724,486	82,534
1876.....	248,638	4,995	1891.....	971,259	77,827
1877.....	301,317	4,829	1892.....	823,733	93,988
1878.....	327,959	5,468	1893.....	960,312	102,827
1879.....	306,648	8,468	1894.....	1,103,694	89,786
1880.....	432,188	14,217	1895.....	1,011,235	96,836
1881.....	395,382	14,245	1896.....	1,106,661	116,774
1882.....	412,682	37,576	1897.....	986,130	101,848
1883.....	486,811	44,388	1898.....	1,150,029	99,189
1884.....	474,405	62,665	1899.....	1,293,169	101,004
1885.....	427,937	71,003	1900.....	1,787,777	62,776
1886.....	520,703	78,443	1901.....	1,573,661	53,894
1887.....	580,965	89,098	1902.....	2,090,268	23,453

TABLE 5.

COAL.

COAL.

EXPORTS.—NOVA SCOTIA AND BRITISH COLUMBIA.

Exports.

Calendar Year.	Nova Scotia.		*British Columbia.	
	Tons.	Value.	Tons.	Value.
1874.....	252,124	\$647,539	51,001	\$ 278,180
1875.....	179,626	404,351	65,842	356,018
1876.....	126,520	263,543	116,910	627,754
1877	173,389	352,453	118,252	590,263
1878	154,114	293,795	165,734	698,870
1879..	113,742	203,407	186,094	608,845
1880	199,552	344,148	219,878	775,008
1881.....	193,081	311,721	187,791	622,965
1882.....	216,954	390,121	179,552	628,437
1883.	192,795	336,088	271,214	946,271
1884.....	222,709	430,330	245,478	901,440
1885.....	176,287	349,650	250,191	1,000,764
1886	240,459	441,693	274,466	960,649
1887	207,941	390,738	356,657	1,262,552
1888	165,863	330,115	405,071	1,605,650
1889.....	186,608	396,830	470,683	1,918,263
1890.....	202,387	426,070	508,882	1,977,191
1891.....	194,867	417,816	767,734	2,958,695
1892.....	181,547	407,980	599,716	2,317,734
1893.	203,198	470,695	708,228	2,693,747
1894	310,277	633,398	770,439	2,855,216
1895.....	241,091	534,479	728,283	2,692,562
1896.....	380,149	787,270	679,799	2,507,752
1897.....	307,128	642,754	630,341	2,221,737
1898.....	309,158	629,363	813,843	2,948,428
1899†.....	459,260	827,941	781,809	2,947,369

*See foot-note, table 16.

†Since 1899, exports by provinces have not been published in Trade and Navigation Report.

COAL.

TABLE 6.

COAL.

Imports of
bituminous.

IMPORTS OF BITUMINOUS COAL.

Fiscal Year.	Tons.	Value.	Fiscal Year.	Tons.	Value.
1880.....	457,049	\$1,220,761	1892.....	1,615,220	\$4,099,221
1881.....	587,024	1,741,568	1893.....	1,603,154	3,967,764
1882.....	636,374	1,992,081	1894.....	1,359,509	3,315,094
1883.....	911,629	2,995,198	1895.....	1,444,928	3,321,387
1884.....	1,118,615	3,613,470	1896.....	1,533,489	3,299,025
1885.....	1,011,875	3,197,539	1897.....	1,543,476	3,254,217
1886.....	930,949	2,501,554	1898.....	1,684,024	3,179,595
1887.....	1,149,792	3,126,225	1899.....	2,171,358	3,691,946
1888.....	1,231,234	3,451,661	1900.....	2,439,764	4,310,964
1889.....	1,248,540	3,255,171	1901.....	2,516,392	4,956,025
1890.....	1,409,282	3,528,969	1902*	3,047,392	5,712,068
1891.....	1,598,855	4,060,896			

*Duty, 53c. per ton.

TABLE 7.

COAL.

Imports of
anthracite.

IMPORTS OF ANTHRACITE COAL.

Fiscal Year.	Tons.	Value.	Fiscal Year.	Tons.	Value.
1880.....	516,729	\$1,509,960	1892.....	1,479,106	\$5,640,346
1881.....	572,092	2,325,937	1893.....	1,500,550	6,355,285
1882.....	638,273	2,666,356	1894.....	1,530,522	6,354,040
1883.....	754,891	3,344,936	1895.....	1,404,342	5,350,627
1884.....	868,000	3,831,283	1896.....	1,574,356	5,667,096
1885.....	910,824	3,909,844	1897.....	1,457,295	5,695,168
1886.....	995,425	4,028,050	1898.....	1,460,701	5,874,685
1887.....	1,100,165	4,423,062	1899.....	1,745,460	6,490,509
1888.....	†2,138,627	5,291,875	1900.....	1,654,401	6,602,912
1889.....	1,291,705	5,199,481	1901.....	1,933,283	7,923,950
1890.....	1,201,335	4,595,727	1902*	1,652,451	7,021,939
1891.....	1,399,067	5,224,452			

*Coal anthracite, and anthracite coal dust. Duty free.

†In Table 7, Imports of Anthracite Coal, a very considerable increase will be noticed in 1888 over 1887, an increase of over ninety-four per cent, the falling off again in 1889 being quite as remarkable. The average values per ton for the three years 1887, 1888 and 1889, were \$4.02, \$2.47 and \$4.03 respectively. Although a duty of fifty cents per ton on anthracite coal was removed May 13, 1887, it is hardly thought this would account for the changes indicated, and unless some error may possibly have crept into the Trade and Navigation Report, no explanation is available.

TABLE 8.
COAL.
IMPORTS OF COAL DUST.

COAL.

Imports of
dust.

Fiscal Year.	Tons.	Value.	Fiscal Year.	Tons.	Value.
1880.....	3,565	\$ 8,877	1892.....	82,091	\$39,840
1881.....	337	666	1893.....	109,585	44,474
1882.....	471	900	1894.....	117,573	49,510
1883.....	8,154	10,082	1895.....	181,318	52,221
1884.....	12,782	14,600	1896.....	210,386	53,742
1885.....	20,185	20,412	1897.....	225,562	59,609
1886.....	36,230	36,996	1898.....	229,445	45,556
1887.....	31,401	33,178	1899.....	276,547	44,717
1888.....	28,808	34,730	1900.....	330,174	98,349
1889.....	39,980	47,139	1901.....	414,432	275,559
1890.....	53,104	29,818	1902*	489,548	264,550
1891.....	60,127	36,130			

*Duty, 20 p. c., not over 13c. per ton.

An approximation of the consumption of coal in Canada sufficiently accurate for purposes of comparison may be made as follows, if we assume the figures of imports for the fiscal year to represent closely enough the importation during the calendar year.

	Tons.	Tons.
Production, Table 3.....	7,193,142	
Exports of coal the produce of Canada, Table 4.....	2,090,268	
Home consumption of Canadian coal.....		5,102,874
Imports of bituminous, anthracite and coal dust Tables 6, 7 and 8.....	5,189,391	
Exports of coal not the product of Canada....	23,453	
Home consumption of imported coal.....		5,165,938
Total consumption of coal in Canada, home and imported.....		10,268,812

Table 9 embodies similar calculations for each year since 1886. Therein is shown the consumption of Canadian and imported coal and the percentage of each as well as the total production per capita. It will be seen that not only the total consumption, but the consumption per capita also has been steadily increasing.

It will be observed too that the proportion of the consumption mined in Canada was greater in 1902 than in any previous year.

An examination of the relation of the total production in Canada, to the amount of coal consumed in the country shows, that in 1902

COAL.

the production amounted to over 70 per cent of the consumption as compared with 65.8 per cent in 1901 and 68.5 per cent in 1900. In 1890 the proportion was 62.4 per cent, and in 1886, 60.8 per cent.

TABLE 9.

COAL.

Consumption.

CONSUMPTION OF COAL IN CANADA.

Calendar Year.	Canadian.	Imported.	Total.	Percentage Canadian.	Percentage Imported.	Consumption per capita.
	Tons.	Tons.	Tons.			Tons.
1886.....	1,595,950	1,884,161	3,480,111	45.9	54.1	.758
1887.....	1,848,365	2,192,260	4,040,625	45.7	54.3	.871
1888.....	2,013,925	3,314,353	5,328,278	37.8	62.2	1.137
1889.....	1,992,988	2,490,931	4,483,919	44.4	55.6	.946
1890.....	2,360,196	2,581,187	4,941,383	47.8	52.2	1.031
1891.....	2,606,490	2,980,222	5,586,712	46.7	53.3	1.153
1892.....	2,464,012	3,082,429	5,546,441	44.4	55.6	1.133
1893.....	2,823,187	3,110,462	5,933,649	47.6	52.4	1.198
1894.....	2,743,376	2,917,818	5,661,194	48.5	51.5	1.130
1895.....	2,467,109	2,933,752	5,400,861	45.7	54.3	1.066
1896.....	2,639,055	3,206,456	5,845,511	45.1	54.9	1.140
1897.....	2,799,977	3,124,485	5,924,462	47.3	52.7	1.143
1898.....	3,022,553	3,274,981	6,297,534	48.0	52.0	1.200
1899.....	3,631,882	4,092,361	7,724,243	47.0	53.0	1.454
1900.....	3,820,889	4,361,563	8,182,452	46.7	53.3	1.521
1901.....	4,653,691	4,810,213	9,463,904	49.1	50.9	1.761
1902.....	5,102,874	5,165,938	10,268,812	49.7	50.3	1.877

Nova Scotia. NOVA SCOTIA.

Detailed statistics of the production of coal in the province are given in Tables 10, 11, 12 and 13.

The production amounted in 1902 to 5,161,316 tons, being an increase over that of the previous year of over 24 per cent. The average value of the production for the year was about \$2 per long ton.

TABLE 10.
COAL.

NOVA SCOTIA :—OUTPUT, SALES, COLLIERY CONSUMPTION, AND PRODUCTION.

Calendar Year.	Output, Tons, 2,240 lbs.	Sales, Tons, 2,240 lbs.	Colliery Consump- tion, Tons, 2,240 lbs.	Production* Tons, 2,240 lbs.	Output, Tons, 2,000 lbs.	Sales, Tons, 2,000 lbs.	Colliery Consump- tion, Tons, 2,000 lbs.	Production* Tons, 2,000 lbs.	Price per Ton, 2,240 lbs.	Value of production.
1872.....	880,950	785,914	110,341	896,255	986,664	880,224	123,582	1,003,806	\$1 75	\$1,563,446
1873.....	1,051,467	881,106	108,398	989,504	1,177,643	986,839	121,406	1,108,245	1 75	1,731,632
1874.....	872,720	749,127	119,582	868,709	977,446	839,022	133,932	972,954	1 75	1,520,240
1875.....	781,165	706,795	124,110	830,905	874,905	791,610	139,003	930,613	1 75	1,454,084
1876.....	709,646	634,207	113,788	747,995	794,804	710,312	127,443	837,765	1 75	1,308,991
1877.....	757,496	687,065	98,841	785,906	848,396	768,513	110,702	880,215	1 75	1,375,339
1878.....	770,603	693,511	88,627	782,138	863,075	776,732	99,262	875,994	1 75	1,388,741
1879.....	788,271	698,624	84,787	773,411	882,863	771,259	94,961	866,220	1 75	1,353,469
1880.....	1,032,710	954,659	96,831	1,051,490	1,156,635	1,069,218	108,451	1,177,669	1 75	1,840,108
1881.....	1,124,270	1,035,014	107,888	1,142,902	1,239,183	1,159,216	120,834	1,280,060	1 75	2,000,079
1882.....	1,365,811	1,250,179	111,381	1,361,560	1,523,708	1,400,200	124,747	1,524,947	1 75	2,382,730
1883.....	1,422,553	1,297,523	111,949	1,409,472	1,593,269	1,453,226	125,383	1,578,609	1 75	2,466,576
1884.....	1,389,295	1,261,650	116,769	1,378,419	1,556,011	1,413,048	130,781	1,543,829	1 75	2,412,233
1885.....	1,352,205	1,254,510	127,624	1,382,134	1,514,470	1,405,051	142,939	1,547,990	1 75	2,418,735
1886.....	1,502,611	1,373,666	142,421	1,516,087	1,632,924	1,538,506	159,512	1,688,018	1 75	2,653,152
1887.....	1,670,830	1,519,684	139,777	1,659,461	1,871,330	1,702,046	156,550	1,853,696	1 75	2,904,067
1888.....	1,776,128	1,576,692	157,443	1,734,135	1,989,263	1,765,895	176,336	1,942,231	1 75	3,034,735
1889.....	1,756,279	1,555,107	158,131	1,713,238	1,967,032	1,741,720	177,107	1,918,827	1 75	3,098,167
1890.....	1,984,001	1,785,111	161,240	1,947,351	2,222,081	2,000,444	180,589	2,181,033	1 75	3,407,864
1891.....	2,044,784	1,849,945	174,983	2,024,928	2,290,158	2,071,838	195,981	2,267,919	1 75	3,543,624
1892.....	1,942,780	1,752,934	175,082	1,928,026	2,175,913	1,963,286	196,103	2,159,389	1 75	3,374,046
1893.....	2,223,042	1,977,543	206,426	2,182,968	2,489,807	2,214,848	230,076	2,444,924	1 75	3,890,194
1894.....	2,250,631	2,060,920	196,206	2,257,126	2,530,707	2,308,231	219,751	2,527,982	1 75	3,949,970
1895.....	1,999,756	1,783,098	193,639	1,986,737	2,239,727	2,008,270	216,875	2,226,145	1 75	3,476,790
1896.....	2,292,675	2,046,828	192,975	2,289,803	2,567,796	2,292,447	216,132	2,508,579	1 75	3,919,655
1897.....	2,340,051	2,044,672	181,716	2,226,368	2,620,835	2,290,032	203,522	2,493,554	1 75	3,896,179
1898.....	2,262,656	2,121,126	167,428	2,288,554	2,334,175	2,375,661	187,519	2,563,180	1 75	4,004,970
1899.....	2,805,443	2,633,989	177,460	2,811,449	3,203,286	2,950,067	198,755	3,143,822	2 00	5,622,898
1900.....	3,298,791	2,998,737	236,563	3,235,300	3,694,646	3,363,585	264,961	3,623,536	2 50	8,088,250
1901.....	3,411,127	3,098,791	301,434	3,712,551	4,279,587	3,820,462	337,606	4,158,068	1 75	6,496,982
1902.....	4,725,480	4,228,120	379,198	4,606,318	5,292,538	4,736,614	424,702	5,161,316	2 00	9,216,636

* This Production is obtained by adding Sales and Colliery Consumption. For sales previous to 1872, see report of the Department of Mines Nova Scotia, 1883, page 68.

COAL.
Nova
Scotia.

COAL.

Nova Scotia.

TABLE 11.
COAL.
NOVA SCOTIA :—COAL TRADE BY COUNTIES.

CALENDAR YEAR.	CUMBERLAND.		PICTOU.		CAPE BRETON.		OTHER COUNTIES.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.
1st quarter.....	150,993	111,097	126,349	103,482	783,718	567,542	20,043	16,214
2nd "	143,515	126,137	142,015	129,274	950,189	886,849	33,618	22,976
3rd "	163,862	151,087	174,944	164,203	1,088,652	1,106,589	37,050	30,770
4th "	163,421	150,664	191,997	173,181	1,064,344	950,266	57,798	46,283
Total, 1902.....	621,791	538,985	635,305	570,140	3,886,903	3,511,246	148,539	116,243
" 1901.....	538,773	447,616	533,340	480,349	3,116,641	2,888,610	40,303	23,887

TABLE 12.

COAL.

COAL.

Nova Scotia.

NOVA SCOTIA:—OUTPUT BY COLLIERIES DURING THE CALENDAR YEAR, 1902.

Colliery.	Tons, 2,000 lbs.	Colliery.	Tons, 2,000 lbs.
<i>Cumberland County.</i>		<i>Inverness County.</i>	
Chignecto.....	4,607	Mabou.....	1,120
Joggins.....	58,580	Pt. Hood.....	57,188
Jubilee.....	883	Broad Cove.....	76,749
Scotia.....	1,047	<i>Victoria County.</i>	
Springhill.....	554,322	New Campbellton.....	13,481
Strathcona.....	2,352	<i>Cape Breton County.</i>	
<i>Pictou County.</i>		Dominion Coal Co.....	3,555,134
Acadia.....	337,418	Nova Scotia Steel and Coal Co.....	296,338
Nova Scotia Steel and Coal Co.....	35,766	Gowrie and Blockhouse....	26,208
Intercolonial.....	242,122	Sydney.....	9,223
		Total.....	5,292,538

TABLE 13.

COAL.

NOVA SCOTIA:—DISTRIBUTION OF COAL SOLD.

Markets.	Calendar Years.			
	1901.		1902.	
	Tons, 2,000 lbs.	Per cent.	Tons, 2,000 lbs.	Per cent.
Nova Scotia, transported by land.....	757,975	19·8	468,658	9·9
" " sea.....	533,569	14·0	1,175,644	24·8
Total, Nova Scotia.....	1,291,544	33·8	1,644,302	34·7
New Brunswick.....	366,976	9·6	358,664	7·6
Prince Edward Island.....	78,324	2·1	70,316	1·5
Quebec.....	1,315,935	34·4	1,492,902	31·5
Newfoundland.....	124,265	3·3	118,041	2·5
United States.....	623,390	16·3	1,004,650	21·2
West Indies.....	.....	.....	6,700	·1
Other countries.....	20,028	·5	41,089	·9
Total.....	3,820,462	100·0	4,736,614	100·0

NEW BRUNSWICK.

New
Brunswick.

The production of coal in this province in 1902 was 18,795 tons valued at \$39,680, a slight increase in quantity over the previous year, but realizing a somewhat lower price per ton at the mines.

COAL.
New
Brunswick.

TABLE 14.

COAL.
NEW BRUNSWICK :—PRODUCTION.

Calendar Year.	Tons.	Value.	Value per ton.
1887.....	10,040	\$ 23,607	\$2 35
1888.....	5,730	11,050	1 93
1889.....	5,673	11,733	2 07
1890.....	7,110	13,850	1 95
1891.....	5,422	11,030	2 03
1892.....	6,768	9,375	1 39
1893.....	6,200	9,837	1 59
1894.....	6,469	10,264	1 59
1895.....	9,500	14,250	1 50
1896.....	7,500	11,250	1 50
1897.....	6,000	9,000	1 50
1898.....	6,160	9,240	1 50
1899.....	10,528	15,792	1 50
1900.....	10,000	15,000	1 50
1901.....	17,630	51,857	2 94
1902.....	18,795	39,680	2 11

Northwest
Territories.

NORTHWEST TERRITORIES.

One of the main features to record, in connection with coal mining operations in the North-west Territories in 1902 is the large output of coal from the new collieries at Frank, Alberta, on the Crows Nest Pass branch of the Canadian Pacific Railway.

The total product of the Territories for the year has been returned as 478,129 tons valued at \$1,110,521 and made up as follows :—

	Tons.
Estevan and Coalfields.....	70,400
Lethbridge.....	153,703
Miscellaneous small mines.....	15,841
Anthracite and Canmore.....	107,950
Frank and Blairmore.....	125,325
Yukon district.....	4,910
	478,129

Of this amount 16,550 tons is anthracite coal and the balance bituminous and lignite.

* Since writing the above the annual report of the Department of Public Works of the Northwest Territories for 1902 has been received in which the output of the coal mines of the Territories (not including the Yukon) is given as:—

Bituminous and lignite	494,087 tons
Anthracite coal	16,587 "
total.....	510,674 "

Although the figures of production in the present report represent sales and shipments only, it is still possible that they are incomplete owing to there being so many producers of coal on a small scale in the Territories.

TABLE 15.
COAL.
NORTH-WEST TERRITORIES :—PRODUCTION.

COAL.
North-west
Territories.

Calendar Year.	Tons.	Value.	Value per ton.
1887.....	74,152	\$ 157,577	\$ 2 13
1888.....	115,124	183,354	1 59
1889.....	97,364	179,640	1 85
1890.....	128,953	198,498	1 54
1891.....	174,131	437,243	2 51
1892.....	184,370	469,930	2 55
1893.....	238,395	598,745	2 51
1894.....	199,991	488,980	2 45
1895.....	185,654	414,064	2 23
1896.....	225,868	606,891	2 69
1897.....	267,163	667,908	2 50
1898.....	340,088	825,220	2 43
1899.....	334,600	811,500	2 43
1900.....	351,950	839,375	2 38
1901.....	391,139	1,008,917	2 58
1902.....	478,129	1,110,521	2 32

BRITISH COLUMBIA.

British
Columbia.

The total sales and shipments including colliery consumption and not including coal used for making coke were in 1902 1,370,448 long tons or 1,534,902 short tons, being a decrease from the previous year of about 7·5 per cent. 244,232 long tons were used for making coke during the year, and 26,946 long tons were added to stock, so that the total output of the collieries for the year was 1,641,626 long tons.

Statistics of output, home consumption, quantity sold for export, etc., are shown in Table 16.

COAL.

British
Columbia.

TABLE 16.

COAL.

BRITISH COLUMBIA :—PRODUCTION.

Calendar Year.	Output Tons, 2,240 lbs.	Home Con- sumption, Tons, 2,240 lbs.	Sold for Export, Tons, 2,240 lbs. †	PRODUCTION.*		Price per ton, 2,240 lbs.	Value.
				Tons, 2,240 lbs.	Tons, 2,000 lbs.		
1836-52..	10,000	From 1836 to 1873 inclu- sive, the output is taken as production.			11,200	4 00	40,000
1852-59..	25,398				28,446	4 00	101,592
1859†...	1,989				2,228	4 00	7,966
1860.....	14,247				15,957	4 00	56,988
1861.....	13,774				15,427	4 00	55,096
1862.....	18,118				20,292	4 00	72,472
1863.....	21,345				23,906	4 00	85,360
1864.....	23,632				32,068	4 00	114,528
1865.....	32,819				36,757	4 00	131,276
1866.....	25,115				28,129	4 00	100,460
1867. . .	31,239				34,988	4 00	124,956
1868.....	44,005				49,286	4 00	176,020
1869.....	35,802				40,098	4 00	143,208
1870.....	29,843				33,424	4 00	119,372
1871-2-3.	148,459				166,274	4 00	593,836
1874.....	81,547	25,023	56,038	81,061	90,788	3 00	243,183
1875.....	110,145	31,252	66,392	97,644	109,361	3 00	292,932
1876.....	139,192	17,856	†122,329	140,185	157,007	3 00	420,555
1877.....	154,052	24,311	115,381	139,692	156,455	3 00	419,076
1878.....	170,846	26,166	164,682	190,848	213,750	3 00	572,544
1879.....	241,301	40,294	192,096	232,390	260,277	3 00	697,170
1880.....	267,595	46,513	225,849	272,362	305,045	3 00	817,086
1881.....	228,357	40,191	189,323	229,514	257,056	3 00	688,542
1882.....	232,139	56,161	232,411	288,572	323,201	3 00	865,716
1883.....	213,299	64,786	149,567	214,353	240,075	3 00	643,059
1884.....	394,070	87,388	306,478	393,866	441,130	3 00	1,181,598
1885.....	365,596	95,227	237,797	333,024	372,987	3 00	999,072
1886.....	326,636	85,987	249,205	335,192	375,415	3 00	1,005,576
1887.....	413,360	99,216	334,839	434,055	486,142	3 00	1,302,165
1888.....	489,301	115,953	365,714	481,667	539,467	3 00	1,445,001
1889.....	579,830	124,574	443,675	568,249	636,439	3 00	1,704,747
1890.....	678,140	177,075	508,270	685,345	767,586	3 00	2,056,035
1891.....	1,029,097	202,697	806,479	1,009,176	1,130,277	3 00	3,027,528
1892.....	826,335	196,223	640,579	836,302	937,218	3 00	2,510,406
1893.....	978,294	207,851	768,917	976,768	1,093,980	3 00	2,930,304
1894.....	1,012,953	165,776	827,642	993,418	1,112,628	3 00	2,980,254
1895.....	939,654	188,349	756,334	944,633	1,058,045	3 00	2,834,049
1896.....	894,882	261,984	634,238	896,222	1,003,769	3 00	2,688,666
1897.....	892,296	290,310	619,860	910,170	1,019,390	3 00	2,730,510
1898.....	1,136,015	374,953	752,863	1,127,816	1,263,154	3 00	3,383,448
1899.....	1,306,324	526,058	751,711	1,277,769	1,431,101	3 00	3,833,307
1900.....	1,590,178	535,084	914,184	1,449,268	1,623,180	3 00	4,347,804
1901.....	1,691,557	568,440	914,163	1,482,603	1,660,515	3 00	4,447,809
1902.....	1,641,626	593,639	776,809	1,370,448	1,534,902	3 00	4,111,344

*This production is obtained by adding 'Home Consumption' and 'Sold for Export,' †52,935 of this amount was exported as sales without the division into the 'Home Consumption' and 'Sold for Export.'

‡The figures in the 'Sold for Export' column do not agree as they should with those given in Table 5, the only explanation being that the data in the two cases are from different sources, and it has not been possible to find out the cause of the difference.

† Two months only.

Statistics of coal production in 1902 are given in the Annual Report of the Minister of Mines for the province as follows :

COAL
British
Columbia.
Statistics
production.

SALES AND OUTPUT FOR YEAR. Tons of 2240 lbs.	Tons.	Cwt.	Tons.	Cwt.
Sold for consumption in Canada	422,466	13		
" export to U.S.A.	775,300	11		
" " to other countries	1,508			
Total sales	1,199,275	04		
Used under colliery boilers &c.	171,172	15		
Total sales and colliery consumption			1,370,447	19
Used in making coke			244,232	
			1,614,679	19
Stock on hand first of year	5,704	17		
" " last of year	32,651			
Difference added to stock during the year			26,946	03
Output of collieries for year			1,641,626	02

Statistics of labour and wages are given in the same report as follows :

Statistics of
labour and
wages.

Number of hands employed, daily wages paid etc.

CHARACTER OF LABOUR.	UNDERGROUND.		ABOVE GROUND.		TOTAL.	
	No. of employees	Average daily wage	No. of employees	Average daily wage	No. of employees	Average daily wage
Supervision and clerical assistance	63	\$ 4 30	48	\$ 4 85	111	\$ 4 57
Whites—						
Miners	1,625	4 30			1,625	4 30
Miners' helpers	494	2 40			494	2 40
Labourers	569	2 73	206	2 34	775	2 53
Mechanics and skilled labour	47	2 81	199	3 10	246	2 95
Boys	133	1 42	23	1 15	156	1 28
Japanese	38	1 37	46	1 12	84	1 24
Chinese	132	1 37	388	1 21	520	1 29
Totals	3,101		910		4,011	

In view of the fact that 75 per cent of the production of Vancouver island collieries is exported to California, the following statistics of

COAL.

receipts of coal in the Californian market are given as illustrating the position which British Columbia coal occupies in this market :

Whence derived.	1901.	1902.
	Tons, 2,240 lbs.	Tons, 2,240 lbs.
British Columbia.....	710,330	691,732
Australia.....	175,959	137,328
England and Wales.....	52,270	55,621
Scotland.....		1,600
Eastern (Cumberland and Anthracite).....	27,370	24,133
Seattle (Washington).....	240,574	165,237
Tacoma.....	433,817	209,358
Mount Diable, Coos Bay and Tesla.....	143,318	111,209
Japan and Rocky Mountains.....	51,147	47,380
Totals.....	1,834,785	1,445,598

Coal
producers.

Following is a list of the principal coal producers in Canada.

NOVA SCOTIA :—

Inverness Railway and Coal Company..Broad Cove, C.B.
 Gowrie and Blockhouse Collieries, Ltd ..Port Morien, C.B.
 Mabou Coal Mining Company, Ltd.....Mabou, C.B.
 Port Hood Coal Company, Ltd.....Port Hood, C.B.
 Cape Breton Coal Mining Co., Ltd.....New Campbellton, C.B.
 Dominion Coal Co., Ltd.....Sydney, C.B.
 Sydney Coal Company, Ltd.....Sydney Mines C.B.
 Acadia Coal Co., Ltd.....Stellarton, N.S.
 Nova Scotia Steel & Coal Co., Ltd.....New Glasgow, N.S.
 Intercolonial Coal Mining Co., Ltd.....Westville, N.S.
 Cumberland Railway and Coal Co., Ltd..Springhill, N.S.
 Canada Coals and Railway Co., Ltd....Joggins Mines, N.S.
 Minudie Coal Co., Ltd.....River Hebert, N.S.
 Strathcona Coal Co.....River Hebert, N.S.
 Messrs Ripley and Blenkhorn (Scotia Mine)

NEW BRUNSWICK :—

New Brunswick Coal & Railway Company..Fredericton, N.B.

NORTH WEST TERRITORIES :—

Souris Coal Mining Company, Ltd.....R. R. Taylor, Manag-
 ing Director, Winni-
 peg, Man.

P. C. Duncan.....	Estevan, Assa.	COAL
Frank Gillespie.....	Medicine Hat, Assa.	Coal
Joseph Cully.....	" "	producers.
Crockford Bros.....	" "	
Alberta Railway and Coal Co....	Lethbridge, Alta.	
Alberta Coke and Coal Co., (Martin B. Holway).....	Cowley, "	
R. J. Galbraith.....	" "	
E. V. Wilson.....	Livingston, "	
Blackfoot Indian Agency, J. A. Markle, agent.....	Gleichen, "	
J. T. Cooper.....	Calgary, "	
J. A. Bangs.....	" "	
F. Barnes.....	Clover Bar, "	
Daly and Lindsay.....	" "	
Keith Fulton and Fowler.....	" "	
E. Chevigny.....	Morinville, "	
Wm. Humberstone.....	Edmonton, "	
Milner and Blatchford.....	" "	
W. J. Baldwin.....	" "	
Bishopric, Grierson and Mays.....	" "	
Leon Moret.....	Ft. Saskatchewan, Alta	
Fishburn and Procter.....	Blairmore, Alta.	
The Canadian Am. Coal and Coke Co....	" "	
United Gold Fields of British Columbia.	" "	
International Coal and Coke Co.....	" "	
The H. W. McNeil Co., Ltd.....	Anthracite "	

YUKON DISTRICT :—

North American Transportation and Trading Co., Cliff Creek Mines	Dawson.
Alaska Exploration Co., Rock Creek Mine.	"
R. S. Ames and Geo. Miller, Five Fingers Mine.....	"

BRITISH COLUMBIA :—

Crows Nest Pass Coal Co., Ltd.....	Fernie, B.C.
Western Fuel Co.....	Nanaimo, B.C.
Wellington Colliery Co., Ltd	Victoria, B.C.

COAL.

Coke.

Production.

COKE.

The sales of coke in 1902 amounted to 502,043 tons, valued at \$1,519,185, being an increase over the production of the previous year of 136,512 tons, or 37 per cent in quantity, and \$290,960, or over 23 per cent in value. The increase is to be all credited to the province of Nova Scotia, there being a slight falling off in British Columbia.

TABLE 1.

COKE.

ANNUAL PRODUCTION.

Calendar Year.	Tons.	Value.	Value. per Ton.
1886.....	35,396	\$101,940	\$2 88
1887.....	40,428	135,951	3 36
1888.....	45,373	134,181	2 96
1889.....	54,539	155,043	2 84
1890.....	56,450	166,298	2 95
1891.....	57,084	175,592	3 08
1892.....	56,135	160,249	2 85
1893.....	61,078	161,790	2 65
1894.....	58,044	148,551	2 56
1895.....	53,356	143,047	2 68
1896.....	49,619	110,257	2 22
1897.....	60,686	176,457	2 91
1898.....	87,600	286,000	3 26
1899.....	100,820	350,022	3 47
1900.....	157,134	649,140	4 13
1901.....	365,531	1,228,225	3 36
1902.....	502,043	1,519,185	3 03

TABLE 2.

COKE.

PRODUCTION OF COKE BY PROVINCES.

Calendar Year.	Nova Scotia.		British Columbia.	
	Tons.	Value.	Tons.	Value.
		\$		\$
1897.....	41,532	90,950	19,154	85,507
1898.....	48,400	111,000	39,200	175,000
1899.....	62,459	178,767	38,361	171,255
1900.....	61,767	223,395	95,367	425,745
1901.....	222,694	590,560	142,837	637,665
1902.....	363,330	899,930	138,713	619,255

TABLE 3.
COKE.
EXPORTS OF COKE.

Calendar Year.	Tons.	Value.
		\$
1897	2,987	6,078
1898	3,774	8,394
1899	5,557	18,726
1900	41,529	131,278
1901	57,505	176,990
1902	62,568	180,920

Coal.
Coke.
Exports.

TABLE 4.
COKE.
IMPORTS OF OVEN COKE.

Fiscal Year.	Tons.	Value.	Fiscal Year.	Tons.	Value.
		\$			\$
1880	3,837	19,353	1892	43,499	194,429
1881	5,492	26,123	1893	41,821	156,277
1882	8,157	36,670	1894	42,864	176,996
1883	8,943	38,588	1895	43,235	149,434
1884	11,207	44,518	1896	61,612	203,826
1885	11,564	41,391	1897	83,330	267,540
1886	11,858	39,756	1898	135,060	347,040
1887	15,110	56,222	1899	141,284	362,826
1888	25,487	102,334	1900	187,378	506,839
1889	29,557	91,902	1901	308,786	680,138
1890	36,564	133,344	1902 .. Duty free.	267,142	842,815
1891	38,533	177,605			

Imports of
oven coke.

Following is a list of companies making coke in Canada from Canadian coal :—

Nova Scotia.—Acadia Coal Co., Stellarton, N.S.

Intercolonial Coal Mining Co., Westville, N.S.

Nova Scotia Steel and Coal Co., New Glasgow, N.S.

Halifax Electric Tramway Co. (Ltd.), Halifax, N.S.

Dominion Iron and Steel Co. (Ltd.), Sydney, C.B.

British Columbia.—Crows Nest Pass Coal Co. (Ltd.), Fernie, B.C.

Wellington Colliery Co. (Ltd.), Victoria, B.C.

COAL.
Coke.

The production of coke in British Columbia is given in the provincial report as follows :

Sales and Output for the Year.	Tons, 2,240 lbs.	Tons, 2,240 lbs.
Sold for consumption in Canada.....	85,071	123,851
" export to United States.....	38,780	
Total sales		
Stock on hand, first of year.....	186	4,164
" last	4,350	
Diff. added to stock during the year...		
Output for year.....		128,015

Peat.

Peat.—During the past few years many companies have been organized to manufacture peat-fuel from peat bogs in the provinces of Ontario and Quebec. Some of these have met with indifferent success, while others are still in the experimental stage or developing their properties.

Sales of peat during the past three years have been reported as follows :—

	Tons.	Value.
Year 1900.....	490	\$1,200
" 1901	220	660
" 1902.....	475	1,663

*THE COAL FIELDS OF CANADA.

The following short description of the coal fields of Canada will, in connection with the statistics already given, be found illustrative of the coal industry of the country. It has been compiled by Mr Theo. Denis, B. Sc., chiefly from information to be found throughout the Reports of the Geological Survey, supplemented by data taken from other reliable sources. As a guide for reference a full list of the maps published by the Geological Survey of Canada, covering the areas referred to in the course of this summary description has been added at the end of the article ; also a list of references forming a short bibliography of the subject. The maps may be obtained from the librarian of the Survey for the nominal sale prices mentioned in the

*This article, compiled originally by Mr. Theo. Denis, appeared in the Annual Report of the Mines Section for 1898, constituting Part S, Vol. XI of the reports of the Geological Survey Department. In compiling the present article he has not only brought the information up to date but has very much extended its scope.

"List of Publications of the Geological Survey of Canada" and COAL Supplement.

The chief fields are located as follows: In Nova Scotia there are several extensive areas of bituminous coal which have been mined for many years. In New Brunswick is a small area with thin seams, also bituminous. The above are all in rocks of Carboniferous age. In Manitoba and the North-west Territories, very large tracts of the prairie country are underlaid by coal beds, varying in quality from lignite in the east to bituminous in the west, as the foot-hills of the Rocky mountains are approached. In the mountain region itself is a small basin where anthracite is mined. Across the watershed in British Columbia is the Crow's Nest Pass field, now being opened up, and on the Pacific coast are the areas on the east side of Vancouver island, that have long been worked. These coal fields are of Cretaceous age. Coals referable to the same period are also found in the Queen Charlotte islands and in many parts of the interior of British Columbia. These Cretaceous coals are generally bituminous, but anthracite occurs in the Queen Charlotte islands. Tertiary fuels also underlie considerable areas in the interior as well as several tracts along the coast. These are usually lignites or brown coals.

NOVA SCOTIA.

Nova Scotia.

The coal-bearing measures of Nova Scotia belong to the Carboniferous, and are practically confined to the one of its subdivisions generally known as the Coal Measures.

The coal mined in this province is all bituminous in quality.

The following sub-divisions into fields is usually adopted:—

1. The Sydney coal field.
2. The Inverness coal field.
3. The Richmond coal field.
4. The Pictou coal field.
5. The Cumberland coal field.

Sydney Coal Field.

This field is situated in the north-east corner of Cape Breton county, and also takes in a small portion of Victoria county. It occupies a land area of nearly 200 square miles, being about 32 miles long by six wide, and it is limited on three sides by the Atlantic Ocean. The conditions for extraction and shipment are very favourable. There is a remarkable

COAL. absence of faults and the coast affords a number of natural harbours. The greater part of the coal-field is hidden beneath the sea, but the
Nova Scotia. seams can be followed under its bed.

*The measures inclosing the Cape Breton coals are largely composed of argillaceous shales and sandstones, the solidity and coherence of which favour submarine exploitation. As to the general structure, it can be said that the seams appear on the shore, sweep inland, and again enter the ocean, forming segments of ellipses whose centres are out at sea. This structure is observable at Cow Bay, Glace Bay, Lingan and Sydney, these places presenting a series of basins, the seams of which have been correlated, and their equivalence in many cases proved. These basins probably owe their origin to a corrugation of the area by numerous folds which bring the same coal seams repeatedly to the surface along the north-east coast of the island.

The whole coast is deeply indented by bays and channels, approximately coinciding with the axes of these folds, and affording in the sea-cliffs numerous natural sections of the strata and exposures of the coal-seams. Some of these bays also constitute excellent harbours, one of which—Sydney Harbour—situated towards the centre of the district, ranks among the finest and most commodious on the Atlantic coast of North America. The cliffs are generally from thirty to eighty feet high, standing perpendicularly, or frequently overhanging the sea. The country inland is of a gently rolling character, the maximum height being about 250 feet.

Such natural advantages, combined with its highly favourable geographical position, point to this district as probably the most important in the Dominion for the supply of fuel to steamships navigating the Atlantic. During the few months of winter, when the more northerly harbours are closed or obstructed by ice, an outlet is afforded by the railway connecting many of the collieries with Louisburg, a fine harbour, open and safe for shipping at almost any season.

The aggregate thickness of coal in workable seams, outcropping on the shore, and for the most part exposed in the bays and cliffs, is from forty to fifty feet; the seams vary from three to nine feet in thickness. They generally dip at very low angles of five to twelve degrees and appear to be very little affected by faults or disturbances. As the strata all dip seaward, much of the coal will be available in the submarine as well as in the land areas. From experience at the Sydney mines it has been fully established that, with due caution and care, these submarine areas may be worked to a large extent.

*See "Descriptive Note on the Sydney coal-field" by Hugh Fletcher B.A., published by the Geological Survey of Canada 1900.

The coal is of the bituminous or 'soft' variety, with comparatively little diversity in the quality of the different seams; all of which yield a fuel exceedingly well adapted for general purposes, while that of some of them is specially applicable to the manufacture of gas. As compared with the Pictou coal, it is characterized on the whole, by a greater proportion of combustible matter and a smaller proportion of ash; but on the other hand, it usually contains a greater amount of sulphur.

The following tabulation, condensed from the work of the Geological Survey shows the equivalency of the different seams of the field at the different places, together with the thickness of the intervening strata:

Average thickness.	Cow Bay.	Glace Bay.	Lingan.	Sydney Mines.	Boulardarie.
3 feet.....	.....	.....	Seam A.....	.....	Point Aconi.
300 ".....	.....	.....	Carl Seams...	Lloyd's Cove..	Bonar.
6.5 ".....	.....	.....	.....	.....	.....
190 ".....	.....	.....	.....	.....	.....
12 ".....	.....	Hub.....	Barrasois.	Seam B.....	Stubbart.
350 ".....	.....	.....	.....	.....	.....
7 ".....	Block House	Harbour..	David Head..	Sydney Main.	Seam C.
275 ".....	.....	.....	.....	.....	.....
3 ".....	Seam D....	Bouthillier..	Seam D.....	Bryant.	Mill Pond.
90 ".....	.....	.....	.....	.....	.....
4 ".....	Seam E....	Back Pit....	North Head..	Edward	Black Rock.
110 ".....	.....	.....	.....	.....	.....
7 ".....	McAulay. .	Phelan.....	Lingan Main..	Seam F.....	Seam F.
125 ".....	.....	.....	.....	.....	.....
3 ".....	{ South Head.	Ross.	Seam G.....	Collins.	Seam G.
320 ".....	{ Spencer....	Emery....	.....	.....	.....
4 ".....	Long Beach.	Gardiner....	Seam H.....	.....	.....

The correctness of the above correlation is, however, questioned by some. The aggregate thickness of coal in the workable beds outcropping on the shore, ranges from thirty feet at some places to sixty at others. Most of the Sydney coals are well suited for the manufacture of gas, as the following figures show:—

Mines.	Gas, Cubic Feet per ton.	Candle power.	Coke produced.
Little Glace Bay	9,268	15	40 bush.
"	9,700	14.75	39 "
International Mine	10,000	16	1,470 lbs.
Sydney Mines	8,200	8	1,295 "
Gowrie "	9,000	15	1,230 "
Caledonia "	8,900	14.25	36 bush.
Reserve "	9,950	13.17	1,500 lbs.

COAL.

Nova Scotia.

The value of these coals for steam and house purposes is given whenever obtainable in the table of analyses at the end of this article.

The Sydney coal-field was the first one opened in Canada. As early as 1785, work was done on it by the government. This, however, was of a desultory nature. In 1827, systematic and regular mining was begun by the General Mining Association.

The collieries at present in operation in this field are described below. Comparing the descriptions with the tabulation of the seams already given, it will be noted that the greater part of these are not at present under exploitation, although very extensive work has been done at different times on some of them. Should need arise, however, many of these would constitute a very important additional source of supply.

Sydney Mines Colliery.—This colliery was worked by the General Mining Association until 1900, when it was purchased from this corporation by the Nova Scotia Steel and Coal Company. This transaction practically terminated the connection of the General Mining Association with coal mining in Nova Scotia, after a career of nearly three-quarters of a century.

The colliery is situated three miles to the north-east of North Sydney.

Seam, 5 feet 4 inches. Dip 1 in 12.

Shaft, 690 feet deep ; 13 feet diameter.

Worked by pillar and stall and longwall. Safety lamps.

Coal produced in 1902, 270,000 tons.*

Average number of persons employed above and underground, 1,000.

North Sydney Colliery.—Operated by the Sydney Coal Company.

Seam, 4 feet.

Worked by slope, 650 yards.

Method, pillar and stall. Naked lights.

Coal produced in 1902, 7,510 tons. Persons employed, 32.

New Campbellton Colliery.—Operated by the Cape Breton Coal Company.

Situated on the Big Bras d'Or lake.

Seam, 4 feet ; dip, 1 in 5

* These figures of production are only approximate and are here given to illustrate the relative importance of the collieries.

Slope, 600 yards.

COAL.

Coal-cutting machines. Method of working, pillar and stall.

Nova Scotia.

Naked lights.

Coal produced in 1902, 13,443 tons. Persons employed, 36.

Gowrie and Block House Collieries.—Situated on Port Morien or Cow Bay. Operated by the Gowrie and Blockhouse Colliery, Limited. This company was organized in 1898, acquiring properties which had been idle for some time. The coal area controlled by this corporation covers five square miles, comprising leases 193, 146, 194, 206 and 235.

McAulay or Gowrie seam, 5 feet 6 inches. Worked by shaft, 205½ feet deep.

Coal-cutting machines. Coal produced in 1902, 20,000 tons.

Persons employed, 81.

Dominion Coal Company.—This company was incorporated in 1893. It holds a number of leases for a period of ninety-nine years in the coal basins of Cow Bay, Glace Bay and Langan. The collieries which it is operating at present are enumerated below. Besides these, it owns others of importance which are not now being worked, such as the Victoria, Langan, Cow Bay and Old Bridgeport, etc. The company has concentrated its operations on the Glace Bay basin, which it has developed to a great extent. The production of the Dominion Coal Company for 1902 amounted to nearly 3,306,000 tons, giving employment to 3,454 persons.

Caledonia Colliery, Glace Bay Basin.—Situated one mile from Little Glace Bay. Phelan seam worked; 7 to 8 feet.

Worked by pillar and room.

Underground haulage by endless rope.

Output for 1900, 573,298 tons.

Reserve Colliery, Glace Bay Basin.—On Phelan seam, 8 feet thick.

Worked by slopes, pillar and room method.

Endless rope haulage. Output for 1900, 707,927 tons.

International Mine, Glace Bay Basin.—Seam worked 'Harbour' 6 feet.

Method, pillar and room. Endless and tail rope systems of haulage.

Three-compartment shafts. Output for 1900, 249,427 tons.

COAL. *Dominion No. 1, Glace Bay Basin.*—On Phelan seam. Dip, 1 in 14.
Nova Scotia. Worked by pillar and room. Electric underground haulage.

Output for 1900, 602,825.

Dominion No. 2, Glace Bay Basin.—This colliery was opened in 1900. The shaft is a four-compartment one, 37' 11" down to 410 feet where it strikes the Harbour seam and is reduced to 21' 11" down to 850 feet where it strikes the Phelan seam.

Harbour seam $6\frac{1}{2}$ feet, Phelan seam 8 feet.

This mine is equipped for a daily output of 6,000 tons.

Dominion No. 3, Glace Bay Basin.—Opened on Phelan seam in 1900. Mined by pillar and room method.

Entered by slopes two miles from Caledonia Colliery. Endless rope haulage. In 1902, the output of this mine had increased to 1900 tons a day.

Dominion No. 4, Glace Bay Basin.—Slope driven on Emery seam, 5 feet thick, about three quarters of a mile from the Caledonia colliery.

Beside the above mentioned workings, the Dominion Coal Company has erected a coal washing plant on the Sydney and Louisburg railway about three miles from Morien junction. The operation of coal washing by removing the finer stoney debris, diminishes the ash that would otherwise be contained in the material mined, by 41 per cent and the sulphur by 28 per cent. Water for the coal washers is obtained by gravitation from Morrison lake.

Inverness Coal Field.

This comprises a series of narrow areas on a line extending from Judique to Margaree on the western shore of Cape Breton island in the county of Inverness. These areas of productive measures form parts of the rim of a basin, the greater portion of which has been removed by erosion. Seams of coal of workable size have been found at Port Hood, Mabou, Inverness or Broad Cove and Chimney Corner.

At Port Hood the strata run parallel to the shore for about two miles. One seam about 7 feet thick is operated. Considerable work on this seam was done thirty five years ago, but the mine was closed in 1878 and resumed on a large scale in 1899.

At Mabou a small coal field shows several seams of good thickness which outcrop there. At Inverness or Broad Cove, north of Cape Mabou is a coal area in which outcrop several seams ranging in thickness from two to twelve feet. The dip is seaward at an angle of about

twelve degrees. At Chimney Corner Mines other workable seams COAL occur.

Nova Scotia.

Work on some of the coal areas in this field was carried on as far back as 1866, and in places the operations were on a large scale, but subsequently very little development was done until three years ago. A great drawback to the development of these areas, was the lack of shipping facilities; the coast does not offer suitable harbours. In 1900 however, a line of railway was completed from Inverness or Broad Cove to Port Hastings, and was subsequently continued to Point Tupper on the Intercolonial. This gives the field a connection with the railway system of the continent; operations on a large scale have been resumed. There are at present three companies at work.

Inverness Railway and Coal Company, Limited.--This company, formerly called the Inverness and Richmond Railway Company, owns coal areas at Inverness or Broad Cove, Port Hood, Chimney Corner and Margaree Island. Its most extensive operations are at Inverness on a seven foot seam, with a dip of one in seven. The company has a shipping pier at Port Hastings.

Coal produced in 1902, 42,934 tons.

Port Hood Coal Company.--This company incorporated in 1899, operates a colliery at Port Hood on a seven feet seam. Worked by a slope 1,150 feet.

Persons employed in 1902, 92.

Coal produced 38,659 tons.

Mabou Coal Company.--Operates at Mabou, where work, mostly of a development nature, is proceeding on three seams of 7, 8 and 13 feet respectively.

A railway about 6 miles long is projected, connecting the mine with a shipping place at Mabou Harbour.

Richmond Field.

In the south-western portion of Richmond county, coal occurs in several localities.

Extensive explorations have been carried on in this field, and coal has been discovered at Coal Brook, Caribacou, Little River and Sea Coal Bay. Although comparatively large sums were spent between 1863 and 1878, also in 1900 and 1902 on exploration work, very little systematic mining has been done.

COAL.
Nova Scotia.

Coal Brook.—At this place some exploration and drilling were done in 1902. A bore-hole was put down to a depth of 520 feet on the north bank of Coal brook, near the proved outcrop of a seam. The drill was then moved 800 feet to the west, down stream, and a second boring struck coal 1 foot 8 inches thick at a depth of 170 feet. The hole was continued to 1,020 feet but did not strike any other seam of importance. The details of the boring are given in the report of the Department of Mines of Nova Scotia for 1902, and in the Summary Report of the Geological Survey for the year 1902.

Sea Coal Bay.—Here a seam of a thickness of about 11 feet gave, on analysis, such a large proportion of ash as to show it to be of very little use for ordinary purposes.

In his report on this coal field, Mr. Hugh Fletcher, of the Geological Survey, gives a summary of his own observations and of information gathered from various sources. Rep. of Progress, Geol. Survey, 1879-1880.

Pictou Coal Field.

This field, situated almost in the centre of Pictou county, has an area of about 25 square miles. It is 11 miles long, with a maximum width of 3 miles between New Glasgow on the north and Stellarton on the south. The field is therefore small, but the seams are of great size, two being nearly forty feet in thickness.

The district is of a remarkably intricate structure, being cut up by numerous faults of various magnitude, and the productive measures are almost completely surrounded by a girdle of faults. The field is very well situated for railway communication, which advantage, however, is somewhat offset by the physical difficulties encountered due to faulting. It has also been noticed that the seams change their character to a remarkable degree within short distances. The field was opened in 1798, but the first systematic work was contemporary with the development of the Cape Breton field in 1827, when both became the property of the General Mining Association.

The Pictou field is conveniently divided into three districts, viz.:—the Central or Albion, the Western or Westville, and the Eastern or Vale.

In the Albion, four seams have been worked. They are the Main, 38 feet thick, the Deep, 22 to 38 feet, the Third, 10 to 13 feet, and the McGregor, 13 to 20 feet. The measures containing these seams rest conformably on the Millstone Grit. The dip of the coal-bearing

measures varies from the horizontal to over 30 degrees. Several other seams have been reported in this section, but none of them of workable size. COAL.
Nova Scotia.

The Westville section is separated from the Albion section by a downthrow fault, estimated at 2,600 feet. The seams of this section are believed to be equivalent to those of the Albion section. The variation in dip and change of character in short distances are similar in both sections.

The Vale section is in the form of a syncline with east-and-west axes. The thicker and more valuable seams appear in the southern outcrop, where they are worked. Two seams of this section, viz., the McBean and the Six Feet have been extensively worked.

The collieries in operation in the Pictou field are as follows :—

Acadia Colliery.—Operated by the Acadia Coal Company. It is situated at Westville, three miles from Stellarton.

Seam worked 10 feet, dip 27°.

Opened by main slope, over 4,000 feet.

Safety lamps used exclusively.

Albion Colliery.—Operated by the Acadia Coal Company. Situated at Stellarton on the Intercolonial Railway. This important colliery taps four seams, by shafts and long slopes. Work is now carried on on the Third seam 10 to 13 feet, Deep seam over 20 feet, and McGregor 13 to 20 feet.

Safety lamps are used in this colliery.

Vale Colliery.—Operated by the Acadia Coal Company. This colliery is on a six feet seam which is worked on both slopes of a basin ; the dip has an average of 15°. Slope 2,800 feet. This mine was worked with open lights until a couple of years ago, when the management, as a measure of precaution, introduced the use of safety lamps.

The Acadia Coal Company in 1902, produced from the three collieries which it controls about 324,800 tons of coal, giving employment to 835 persons.

Drummond Colliery.—Worked by the Intercolonial Coal Mining Company. Three seams are tapped in this colliery. The Main, 17 feet ; second seam 12 feet and the third seam 8½ feet. The coal produced in 1902 was nearly 231,840 tons. Persons employed 665.

Marsh Colliery.—Operated by the Nova Scotia Steel and Coal Co. This company has held this property for a number of years past, but

COAL. only began actual work on it in 1901. It is situated between New
Nova Scotia. Glasgow and Thorburn on the George McKay or Four Feet seam. Worked by slopes now 1,575 feet long. The coal is shipped to New Glasgow by the Vale Colliery railway and thence to Trenton by the Intercolonial railway. This colliery in 1902 produced 25,488 tons of coal, and employed 95 men.

Cumberland Field.

This is the most westerly of the coal districts of Nova Scotia, a part of it being adjacent to Chignecto Bay.

In this field there are two coal-producing areas, both in Cumberland county. One situated near the coast, may be called the Joggins area, and the other situated about 15 miles to the east of the first at Springhill. The equivalence of the seams in these two basins has not yet been determined. These two coal-bearing areas are separated by a development of Permian strata, and this intervening space is affected by several faults. The coal measures of the Joggins area form a narrow strip some eighteen miles long.

In the Joggins area the following seams of workable size are known: At Joggins two seams, respectively 4 and 6 feet; at River Hebert one 5 feet seam with two shale partings; at Maccan two seams, the upper $2\frac{1}{2}$ and lower $4\frac{1}{2}$ feet; at Chignecto, a seam $9\frac{1}{2}$ feet, of which $2\frac{1}{2}$ feet are shale partings; at the Styles mine a seam 7 feet 8 inches with a S.W. dip of 40° .

At Springhill three seams are at present worked; in Mr. Scott Barlow's reports these three seams are called in descending order: the North or Thirteen feet seam, the East seam, and the West eleven feet, or Black seam. By the courtesy of Mr. J. R. Cowans, the General Manager of the Springhill Collieries, which are operated by the Cumberland Railway and Coal Co., the following section was furnished to the Mines Section of the Geological Survey, through Mr. Hugh Fletcher. The section gives the stratigraphical succession at the Springhill mines as revealed by the mine workings up to 1903. Mr. Fletcher gives the following information in regard to it:—

"This section is original. . . The upper portion is compiled from a horizontal tunnel 502 feet long, between No. 3 and No. 1 seams and another 250 feet long, between No. 1 and No. 2. The remainder is from a tunnel cut across the strata underlying No. 2 seam for 1,122 feet, from the 2,600 ft. level of No. 2. The dip varies from 30° to 38° ."

Section of Coal Measures at Springhill mines, N.S.,
in descending order.

COAL.
Nova Scotia.

	Feet.	Inches.
1 Coal, North or No. 3 seam.....	9	0
2 Strata.....	238	0
3 Coal, East or No. 1 seam.....	10	0
4 Strata.....	118	0
5 Coal, West or No. 2 seam.....	10	0
6 Strata.....	45	5
" "		
7 { Coal 0 1 Stone 0 8 Coal 2 0 Stone 0 2 Coal 0 3 }.....	3	2
8 Strata.....	44	6
" "		
9 { Coal 0 9 Stone 0 3 Coal 1 10 }.....	2	10
10 Strata.....	5	4
11 Coal.....	0	11
12 Strata.....	85	10
13 Coal.....	2	2
14 Strata.....	29	2
15 Coaly shale.....	0	2
16 Strata.....	37	7
17 Coaly shale.....	0	2
18 Strata.....	7	8
19 Coal.....	2	1
20 Strata.....	27	11
21 Coal.....	1	7
22 Strata.....	39	4
23 Coaly shale and coal.....	0	6
24 Strata.....	25	5
25 Coal.....	0	6
26 Strata.....	42	4
" "		
27 { Coal 0 11 Stone 0 3 Coal 1 5 }.....	2	7
28 Strata.....	10	7
" "		
29 { Coal 0 3 Stone 0 7 Coal 2 0 }.....	2	10
30 Strata.....	11	4
31 Coal.....	0	4
32 Strata.....	3	10
33 Coal.....	0	3
34 Strata.....	20	1
35 Coal.....	1	0
36 Strata.....	11	2
37 Coal and coaly shale and stone.....	1	1

COAL—3½

COAL.		Feet.	Inches.
Nova Scotia.	38 Strata.....	8	10
	39 Coal.....	0	4
	40 Strata.....	28	5
	" "		
	41 { Coal 0 3 Stone 0 2 Coal 0 6 }.....	0	11
	42 Strata.....	25	0
	" "		
	43 { Coal 0 0½ Stone 1 7 Coal 0 1 Coaly shale 0 5 }.....	2	1½
	44 Strata.....	35	0
	" "		
	45 { Coaly shale 0 2 Coal 0 2 Coaly shale 0 2 Coal 2 6 }.....	3	0
	46 Strata to face of tunnel.....	5	8
Total thickness.....		963	11½

Joggins Mines—Operated by the Canada Coal and Railway Company. This colliery is situated one mile from the shore of Chignecto Bay. It is connected with the Joggins wharf by a tramway. The nearest railway station is Maccan on the Intercolonial, distant eleven miles, with which it is connected by a standard gauge railway.

Seam worked 4 to 5½ feet thick, dip 17°, on which are two slopes, 2,500 and 2,700 feet; only one of these is at present in operation. Underground haulage by tailrope system. Coal produced in 1902, 64,960 tons, giving employment to 276 persons. Besides this comparatively large producing colliery, there are scattered throughout this area, smaller mines in operation. In 1902 there are records of four such mines having produced a certain amount of coal. These are the Chignecto Mine which produced 2,512 tons, the Strathcona, 2,352 tons, the Jubilee 1,543, the Scotia about 500 tons; besides these, there are others which have been opened and worked for some time.

Springhill Collieries.—Worked by the Cumberland Railway and Coal Co. On three seams 10 feet wide, dip 30°. Worked by slopes. This colliery is connected with the Intercolonial Railway by a branch 5 miles long, and by an extension 25 miles long with Parrsboro' on the Bay of Fundy, from whence shipments by vessels are made.

This colliery, the most important of the Cumberland field, is well equipped and the surface plant is very complete.—The coal is specially

well adapted for steam purposes, and the produce of the mine is largely used by the Intercolonial, Canadian Pacific and Grand Trunk rail-ways. COAL.
Nova Scotia.

Coal produced in 1902, 538,720 tons. Men employed 1,537.

NEW BRUNSWICK.

New
Brunswick.

The discovery of coal in the Province of New Brunswick dates back to 1782.—The most important, and so far, the only field of economic value in this province being that situated at the head of Grand lake, Queens county. This deposit has been worked to a limited extent since 1825. Rocks of Carboniferous age have been recognized over a great part of New Brunswick, but according to the conclusions arrived at by investigation and studies the coal seams occurring in them do not belong to the productive measures corresponding to those of Nova Scotia; and the conditions under which the known coal occurs in New Brunswick are not very favourable for mining on a large scale. Hopes were entertained that south of the Coastal Range the features more closely resembled those of the Nova Scotia coal basins. Deep borings were undertaken at different places, but the results obtained do not seem to be encouraging, for no workable coal-seams were encountered. Therefore, the coal-bearing measures of the province are limited to the Grand Lake field. The area of this field seems to be about 100 square miles. The quality of the coal is excellent but the seams are thin, from 15 to 20 inches. The total quantity of coal underlying this district has been estimated at from 100 to 150 million tons.

Although mining operations were begun more than fifty years ago, they are yet conducted in a small way, and the proximity of the Nova Scotia fields, as well as the limited thickness of the seams would hardly justify the expenditure necessary for exploitation on a large scale. The beds are flat, lying with a cover varying from 2 to 30 feet, rendering it possible in many places to work them opencast. This enables small seams to be worked profitably for the local market, when the stripping does not exceed 8 feet. Beyond this depth it would be more advantageous to work under ground.

MANITOBA AND NORTH WEST TERRITORIES.

Manitoba and
North-west
Territories.

In Manitoba and the North West Territories the coal measures occur in the Cretaceous system or in the Laramie, which may be regarded as its upward continuation. The coal is therefore of more recent age than that of the Atlantic Coast. The quality of the fuel grades from lignite or brown coal as that found in Southwestern Manitoba, to anthracite in the Rocky Mountains. These various grades of coal are

COAL.

Manitoba and
North-west
Territories.

found in measures of nearly the same geological age, the differences depending on the amount of alteration and disturbance undergone by the rocks. Therefore, as might be expected, the quality of the fuel improves as the Rocky mountains are approached. The Souris river country and eastern Assiniboia yield only lignites, whereas in western Alberta the character changes to lignite coal, becoming more and more bituminous as the Foot Hills are reached and in the outer range of the Rocky mountains, steam coal and anthracite are produced.

It is roughly estimated that the coal-bearing region of the North West Territory, between the international boundary and the 56th degree of latitude, has an area of some 65,000 square miles, and although the fossil fuel of the greater part of this is lignite, which is not so valuable as the true coals, yet such deposits possess great importance as sources of supply of fuel for the adjacent farming communities.

Several separate coal-bearing districts or basins have been recognized throughout the region, and in the majority of these, some work has been done, either of a prospecting nature or for local wants, while in some places, coal seams are systematically worked and extensive well-equipped collieries are in operation.

Souris River and Turtle Mountain Fields.—The Souris district is situated in the south-eastern part of Assiniboia and is underlain by several seams of lignite which constitute an almost inexhaustible supply. The use of this fuel in the districts remote from the sources of supply of better grades of coal, is extending rapidly, and the Souris lignite is now used for the generation of steam.

In the vicinity of Estevan, three seams are recognizable over a great part of the region. The upper is four feet thick and is the most constant. The middle is very variable in thickness, reaching in places a maximum of 6 feet. The lower is more strictly speaking a series of seams separated by partings of clay. The quality of the lignite of this last seam is superior to that of the upper one.

Roche Percée and Coalfields mines.—Operated by the Souris Coal Mining Co. This company owns sections 3, 4 and 5, tp. II, range VI, and sections 32, 33 and 34 tp. I, range VI. The seam is about 8 feet worked by adit on the banks of the Souris river. This mode of working presents the objection of considerable upgrade haul to reach the prairie level, and it is probable that work by shaft from the prairie level would decrease the cost of haulage. The mines are well equipped, having air compressors, coal-cutting machines, etc. They are equipped for an output 600 tons a day.

The Turtle Mountain Field is in the south-western part of the province of Manitoba and is separated from the Souris field by a synclinal in which no coal has been recognized as yet. Several coal seams were found on the northern flank of Turtle Mountain, a number of years ago, but so far have not given rise to very active mining operations. There are only small workings to supply local wants.

COAL.
Manitoba and
North-west
Territories.

Belly River Coal Fields.

This coal-bearing region is situated in the southern part of Alberta. According to the results of Dr. Dawson's explorations in that region the outcrop of the seams which occur on the Belly river have been traced northwestward as far as the Red Deer river and southwestward to the 49th parallel, a distance of about 150 miles. The thickness and quality of the seams vary greatly, but on the Belly river and on the lower part of the St. Mary, a length of outcrop of 18 miles may be considered as workable. A list of the principal localities of the region, where natural outcrops of coal and lignite were observed, was published in the report of the Geological Survey for 1882-83-84, Part C.

Outcrops of coal are worked in numerous places, but in the majority of cases to supply only local demand. In Lethbridge, however, on the branch of the Canadian Pacific railway, an important colliery is in operation.

Lethbridge Colliery.—Operated by the Alberta Railway and Coal Company. Seam worked $5\frac{1}{2}$ feet, with a fire-clay parting of 2 to 6 inches. System of working, room and pillar, with coal-cutting machines and endless rope haulage. The mine is equipped for a production of 1,000 tons a day, but it is not worked to its full capacity. The company owns 66 miles of railway, from Lethbridge to Coutts, Alberta.

Cascade Basin.

This is part of the Bow River valley, which is underlain by Cretaceous coal-bearing rocks. It forms a basin or trough running approximately from the northern part of the Kananaskis range, south of latitude 51° , longitude 115° , in a northwesterly direction. Its total area is some 60 square miles. This area, although small, contains much coal. The rocks here have been greatly disturbed; in places the seams assume an almost vertical attitude. Most of the coal is bituminous, although some of the seams have been locally converted to anthracite.

COAL.

Manitoba and
North-west
Territories.

At Marsh's mine, near the south end of the field, are two seams, one of about 15 feet and the other eight feet. Three miles to the north-west of this are several openings into beds of workable size. At Canmore there are three seams of 4 feet, 12 feet and 16 feet, respectively. At Anthracite three seams are now being worked, two of a thickness of 4 feet each and one of 3 feet. All of these seams are situated very near the main line of the Canadian Pacific railway.

The measures in this field are often faulted, and the seams dip to the south-west at an inclination varying from 15 to 60 degrees. At Canmore two of the seams are almost vertical. The field was first opened by the Canadian Anthracite Coal Company in 1886 at Canmore and Anthracite.

Canmore Colliery.—This colliery is worked by the H. W. McNeil Company. The four seams worked vary considerably in thickness from 3 to 6 feet; worked by shaft and room and stall method. The product of the mine is a good bituminous coal.

Anthracite Colliery.—Operated by the H. W. McNeil Company. There are three seams worked which produce anthracite coal. The mine has an output of 100 tons a day. Both the Anthracite and the Canmore collieries are situated on the main line of the Canadian Pacific railway.

In the district around Edmonton there are several small mines operating, supplying the needs of Edmonton itself and the villages and market centres of that region. This industry, however, will certainly grow as the district becomes more thickly settled, and may in time assume great importance.

Blairmore-Frank Coal Fields.

This coal-bearing area is situated on the eastern slope of the main range of the Rocky Mountains and extends in width from Crow's Nest lake for a distance eastward of fourteen miles. Its southern limit would be almost latitude 49° 20' and its northern boundary has not been determined.

In this field a section of the coal measures observed at Cat Mountain gave some 740 feet in which there are present 21 seams of an aggregate thickness of 125 feet 3 inches. Until 1900 very little work had been done in this field, but within the last three years its development has been very active.

Frank Colliery.—This is operated by the Canadian American Coal and Coke Company. It is located on the east flank of Turtle mountain.

Seam worked nine to twelve feet, dip 83° west. Worked by a main entry COAL. run in some 4,500 feet. Output about 500 tons a day, to be increased Manitoba and North-west Territories. shortly. The coal produced is an excellent steam coal, though high in ash.

Lille Collieries.—Operated by the United Gold Fields of British Columbia. The mine is situated on Gold Creek, three and a half miles above the town of Frank. A railway line connects it with the Crow's Nest branch of the Canadian Pacific railway.

Recently another important colliery has been added to these two. It is operated by the International Coal and Coke Company, Blairmore, and is said to be shipping coal, but no particulars are at hand.

Besides these collieries, a great deal of prospecting work has been done in the region, and from all appearances this coal-field will probably grow in importance and become a great factor in the question of the fuel supply of the mining districts and the smelting centres of British Columbia and adjacent parts of the United States.

BRITISH COLUMBIA.

British
Columbia.

In western Canada coal occurs in connection with newer rocks than in the east. Although Carboniferous rocks of great thickness are frequently met in the west, they are all marine deposits, mainly limestones. Ancient swamps and marshes which afforded the conditions giving rise to accumulation of vegetable matter, producing coal beds, existed in the Cretaceous and Tertiary times. In character, the coals of British Columbia range from anthracite to lignite, showing that the grade depends on conditions of metamorphism rather than on age.

Four recognized coal-fields in British Columbia may be named, but mineral fuels are known in many other places, which have only to be worked in order to receive recognition.

The Crow's Nest Pass Field.

The Nanaimo Field.

The Comox Field.

The Queen Charlotte Islands Field.

Crow's Nest Pass Field.

This field is situated immediately west of the summit of the Rocky Mountains, which form the boundary between Alberta and the province of British Columbia. It has a length north and south of

COAL.
British
Columbia.

about thirty five miles and a maximum width of thirteen miles. An east and west line passing through the town of Fernie, divides it into two almost equal parts. On the west it is bounded by the Elk river, and on the east by the main ridge of the Rockies. About 230 square miles are underlain by the coal measures. Coal was discovered in this district many years ago and the first allusion to its existence in the Reports of the Geological Survey dates back to 1883, when Dr. G. M. Dawson approximately examined and defined the field in a preliminary way; however, it was only on the construction of the Crow's Nest Branch of the Canadian Pacific railway, a few years ago, that it became important from an economic standpoint.

The coal occurs in the Cretaceous rocks; it is bituminous in character, and cokes well. Some of the upper seams are said to partake of the character of cannel coal. In a section of the coal measures of this area, in a thickness of 4,700 feet, over 215 feet of coal were observed in beds of from one foot to forty six feet. Of these, at least one hundred feet would be workable, and on this assumption, some 22,600,000,000 tons would be available over the total area of 230 square miles.

There are at present three collieries in this field, working and producing actively. They are all operated by the Crow's Nest Pass Coal Company.

Coal Creek Collieries.—The Crow's Nest Pass Coal Co. was incorporated in 1897 and has operated these collieries since that time. The workings are situated on Coal Creek, about five miles from its mouth. Seams worked, 10 feet, 6 feet and part of a 36 feet seam. They are entered by tunnels. The mine is connected with the Canadian Pacific railway by a spur from the town of Fernie. At this place there are at present over 400 coke ovens of the bee-hive pattern, in operation. Production of this mine in 1902, 267,429 tons, of which about one-half was used in the production of coke.

Michel Colliery.—These workings are situated on the Crow's Nest branch of the Canadian Pacific railway. Work has been done on eight seams which outcrop here, but at present there are three mines in operation and producing, while the others are being developed. There are 200 coke ovens in operation, and 200 more under construction. Production of these collieries in 1902, 117,515 tons, of which 50,000 were converted into coke.

Morrissey Colliery.—Situated on Morrissey creek, about four miles from the Canadian Pacific railway. The colliery is connected with

the Great Northern railway by a branch from Jennings, Montana. COAL.
 Four mines are in operation at Morrissey, and a bank of 200 coke British
 ovens is under construction. Production for 1902, 46,291 tons, to be Columbia
 increased greatly in a near future.

To the north of the Crow's Nest Pass field, in the Elk river trough of Cretaceous rocks, is another development of coal-bearing rocks which has lately attracted some attention. This coal area lies between the Elk river and its tributary Fording river; its southern limit is some twenty-four miles north of the mouth of Michel creek, and the coal-bearing rocks extend northward. In a section of these measures, twelve seams were encountered, aggregating a total thickness of nearly ninety feet of coal. There are at present no means of communication beyond the rough trail along the Elk river, but the construction of a railway to reach this area would not offer any great difficulties. Several extensive concessions have been taken up.

West Kootenay, Kamloops.

In the Kamloops district of the West Kootenay, there are several occurrences of coal and lignite in rocks of Tertiary age. The most important of these known outcrops is on the Nicola river, near the Coldwater river. A list of coal outcrops in this district was given in Dr. G. M. Dawson's report on the Kamloops map sheet, Geological Survey Report, part B, vol. VII, 1894. In his report for 1901 the Provincial Mineralogist for British Columbia mentions that work is going on in this basin, but detailed information is not available.

North Fork, Kettle River.

The following extract from the Summary Report of the Geological Survey for 1901 is interesting as mentioning a new discovery of coal in the West Kootenay District.

"The new coal fields, as they are locally called, are situated about twenty-four miles above the forks of the East Branch on the Main North Fork of the Kettle river, or about fifty-two miles from Grand Forks. Here, as above mentioned, a tertiary outlier rests on the granite The extent of coal-bearing rocks is not large, as they are overlaid by the unproductive volcanic flows and immediately underlain by granite which is exposed on the east bank for the greater part of the distance between the two exposures of coal. Nor have they a wide areal extension, as the granite boulders in the river and tributary creeks testify.

COAL.
British
Columbia.

"Colonel N. E. Linsley, of Spokane, who examined the district after my visit, reports having discovered four seams of coal on the lower (Gilpin's) claim. Of these the upper (seven inches wide) was the largest and was separated from the lowest by 150 feet of tuffa. He also found the area of coal-bearing rocks to be extremely circumscribed. The coal is of very fair quality, coking easily and well."

Nanaimo Coal Field.

This field is situated on the Island of Vancouver, towards its south-eastern part. Its area has been estimated at about 200 square miles. Two seams, at least, of workable thickness are known, but the measures being much folded and cut up by faults, it is very difficult to correlate the beds in the various parts of the field.

The product of both this and the Comox areas is largely exported to California, where it competes successfully with the coals produced in the United States, notwithstanding that it is handicapped by an import duty.

Nanaimo Collieries.—Operated by the Western Fuel Company, which took over the properties of the New Vancouver Coal Mining Co. This latter had been formed in 1862 and reorganized in 1889. Its output is the largest of the coal companies operating in Vancouver island. Figures of production for 1902 are not available, but in 1901, the output amounted to 584,826 tons. The collieries consist of the following workings.

Northfield Colliery.—Situated four miles from Departure bay. Seam worked 2 to 3½ feet thick; dip, 6 degrees; worked by shaft 440 feet deep, and slope at bottom 2,100 feet. System of working, long-wall. This colliery is at present idle.

No. 1, Shaft, Esplanade.—Situated half a mile from the wharfs of Nanaimo harbour.

Seam worked, the 'Harbour'; thickness, 5 to 12 feet; dip, 6 degrees. System of working, pillar and stall.

Haulage. For haulage from the levels, which are in about 2 miles from the foot of the shaft, the company uses electric motors.

Ventilation by Guibal fan, 36 feet in diameter and 12 feet wide. Connected with the Protection island shaft which is used as intake.

Lamps, naked lights.

The workings of this extensive colliery are under the waters of Nanaimo harbour and beneath the surface of Protection island. The

mine is quite safe from invasion by water, being protected by a thick-
ness of rock and earth varying from 400 to 1,200 feet between the
workings and the bed of the harbour. The pillars left in place amount
to two-thirds of the original seam, this large proportion being thought
necessary to insure safety. They will be robbed at a later period.

Protection Island Shaft.—Situated 300 yards from the shipping wharf and half a mile from Nanaimo.

Seams worked, the 'Douglass,' upper and lower. Thickness of upper seam 6 to 8 feet; dip 6 degrees, vertical depth of shaft to seam 670 feet. The lower seam is reached at a depth of 740 feet and is 4 feet thick.

In the upper seam two slopes have been driven, 900 and 600 yards respectively.

System of working, pillar and stall.

The Protection Island shaft is the intake of the system of ventilation which includes Esplanade shaft.

Southfield Colliery.—No. 5. Situated five miles from Nanaimo in the southern part of the area controlled by the Western Fuel Co.

Seam worked varies from 6 to 12 feet in thickness. Dip 6 degrees. Vertical depth of shaft 508 feet.

System of working, pillar and stall.

This part of the field is very much cut up by faults and breaks.

Harewood Mine.—This mine is situated about three miles and a half south-west of Nanaimo. This was worked actively some 25 years ago, and subsequently acquired by the New Vancouver Coal and Land Co. which left it idle for some time. In 1901 work was resumed at this place and the mine produced for a couple of years. The main workings are the Harewood slope on a six foot seam and a shaft which are now connected. Work however, was discontinued in September 1902.

Wellington Colliery, Cranberry District.—Operated by the Wellington Colliery Co.—The colliery is an important producer. The workings consist of No. 1 slope, No. 3 slope, and the Tunnel. The main equipment of the colliery consists of five miles of railway, four locomotives, 350 coal cars, stationary engines, electric power house, &c. The company has wharves and bunkers at Ladysmith, Oyster Harbour. The mining is carried on by pillar and stall. No figures of production are available for 1902, but in 1901 the output of the mine was 405,986 tons.

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Alexandria Colliery.—This is situated in South Nansimo district and is operated by the Wellington Colliery Co. Worked by a slope. The colliery is connected by a short railway line with the E. and N. railway. In 1901 the output of the mine was 68,420 tons. In 1902 no work was carried on, the colliery being allowed to remain idle all year. The Wellington Colliery Co. whose offices are at Victoria employ a staff for prospecting in this and other districts.

Comox Field.

This field is situated on the north-west of the Nanaimo field, from which it is separated by the intervention of crystalline rocks. The Comox area has probably a greater extent of productive measures than the Nanaimo field. Mr. Richardson, late of the Geological Survey, estimated it at 300 square miles, without taking into consideration the seaward extension.

In a section on Brown River, almost the entire thickness of the productive measures is exposed, amounting to 740 feet. In this section nine seams occur, with an aggregate thickness of $16\frac{1}{2}$ feet. At the Union mines a section of 122 feet reveals ten seams aggregating $29\frac{1}{2}$ feet, the thickest being 10 feet.

Wellington Colliery, Cumberland Town, Comox District.—This mine was formerly designated by the name of Union Mines. It is worked by the Wellington Colliery Co., which also operates two other mines in the Nanaimo field. The main workings consist of one slope and two shafts, worked partly by pillar and stall and partly by longwall. Seams worked, three feet and five feet respectively. The surface plant consists mainly of nearly 12 miles of standard gauge railway to shipping wharf; 4 locomotives; steam saw mill; coal washers; 200 beehive coke ovens at the mine, beside 70 at Union.

This company also carries on the manufacture of fire-bricks, from the fire-clay mined in connection with the extraction of the coal.

Queen Charlotte Island Field.

This field is in that part of the Cretaceous area of the province which extends over parts of Graham and Moresby Islands, on both sides of Skidegate Sound.

The coals are anthracite and bituminous, the former comparing favourably with that of Pennsylvania. In the 'Mineral Wealth of British Columbia' Dr. Dawson speaks of the Cowgitz seams on the Skidegate as follows:

'At Cowgitz, the Queen Charlotte Coal Mining Co. about 1871, ^{COAL.} constructed a wharf, houses, tramway, &c., and attempted to work the ^{British} coal seams which have there the character of anthracite, but met with ^{Columbia.} difficulties in following the seams, of which some portions were found to be in a crushed and pulverulent state.

'Though these efforts were not attended with success, the work was not carried far enough to prove that the coal in this vicinity is not of a workable character. Further exploration appears to be fully justified by what is known of the place * * * The beds containing the anthracite are almost vertical, and it is evidently on account of the disturbance and local alteration which it has suffered that the coal has passed into the condition of anthracite. The best seam found had a maximum thickness of a little over 6 feet, while a second outcrop showed 2 feet 5 inches.'

A bed 18 feet thick, of bituminous coal, has been reported on the Ya-Kum river, midway between Skidegate and the head of Masset inlet.

Means of communication with the coast, however, must be provided before this deposit can be utilized.

In 1892 Mr. H. E. Parrish, C.E. and M.E., late of the staff of the Geological Survey of Pennsylvania, examined some coal areas on this island for private parties. After mentioning and describing some prospecting work done at Camp Robertson, section 20, township 5; Camp Anthracite, section 17, township 5; Camp Wilson, section 36, township 9; he concludes with the following remarks:

* "With the knowledge I have of the coal regions of Pennsylvania, acquired there as a mining engineer and on the geological staff of that state, it must gratify you to know that in my judgment you have the best coal field I have seen. Until I visited it, I had no conception such a valuable field existed on the Pacific Coast. You possess a number of beds of unusual thickness, containing coals of superior quality, suitable for all requirements. You have anthracite, first class steam, gas and coking coals, and a bed, over 15 feet thick, excellent for domestic purposes."

Peace River region.

Of the other localities in British Columbia where coal has been observed, the country in the Peace river region is likely to come into

* Report of H. E. Parrish, extracts of which were published in the Report of the Minister of Mines for British Columbia for 1898, p. 1163.

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prominence if the project now being discussed of the building of the Grand Trunk Pacific Railway becomes a fact. The line, as it is now projected, would follow part of the Peace river valley and would pass at a moderate distance from the cañon where Dr. Selwyn and Dr. Dawson observed outcrops of coal.

Dr. Selwyn in his report on the Peace river country in 1875, mentions four seams of good lignite coal, from six inches to two feet in thickness, as occurring on Peace river below the cañon.

As to the coal-bearing character of the country, Dr. Dawson expresses himself as follows: "It would thus appear that while in the region lying between the Athabasca and the Peace rivers, no coal-seams sufficiently thick to be of great economic value have yet been discovered, that coal and lignite of good quality occur in two distinct series of beds. Wherever natural sections of these occur in the valleys of rivers and streams, coal in greater or less quantity is found, and the persistently carboniferous character of the beds, thus abundantly proven. There can be little doubt that beds of a workable character exist in different parts of this district and will be found by further search.

"The promising coal-bearing belt of rocks supposed to belong to the lower sandstones and shales which run south-eastward from the cañon of the Mountain of Rocks to Table Mountain and the lower forks of Pine river, probably extends still further in the same direction, crossing the head-waters of the Wapiti and Smoky rivers above the points reached in my explorations, and forming the south-western side of a synclinal in which the Upper sandstones and shales lie. In this the coals reported by the Indians to exist on the upper parts of these rivers may occur."

In support of these views, it is interesting to quote the following section measured recently by Mr. Hugh Campbell up a small creek on the Peace river cañon.*

	Ft. In.		Ft. In.
Blue shale	10	Shale	20
Shale with hard bands	6	Limestone	3
Sandstones	10	Unseen strata	50
Gray shale	8	Fossiliferous sandstone	30
Impure cannel coal	2	Coal	2 7
Coal, good	9	Shale	9 0
Soft blue shale	7	Coal	0 8
Measures not seen	50	Calcareous shale	12
Limestone	10	Coal	1 4
Sandstone	9	Hard gray shale	20

* From a private letter communicated by Dr. H. M. Ami.

	Ft.	In.		Ft.	In.	COAL
Soft shales.....	20		Dark shale.....	10		British Columbia.
Coal.....	2		Coal.....	2	8	
Shales with bands.....	30		Hard rock.....	2		
Sandstone.....	10		Soft dark shale.....	2	6	
Shale.....	1	3	Coal.....	4	2	
Cannel coal.....	1		Soft clay.....	3		
Shale.....	20		Shale.....	6		
Coal.....	3	10	Limestone.....	6		
Sandstone.....	3		Coal.....	3		
Shale.....	4		Shale.....	5		
Sandstone.....	20		Coal.....	2	6	
Coal.....	1	4	Sandstone.....	8		
Sandstone.....	10		Shale with bands.....	8		
Shale.....	5		Sandstone.....	6		
Sandstone.....	20		Shale.....	1	3	
Limestone.....	4		Coal.....	3		
Shale.....	10		Sand.....	1		
Hard bands.....	50		Coal.....	3		
Limestone.....	4		Dark soft shale.....	2		
Sandstone.....	15					

The measures, according to Mr. Campbell, dip S. 30° E. at an angle of about 13°.

YUKON TERRITORY.

Yukon
Territory.

Lignites and lignitic coals occur in the Tertiary rocks of the valleys of the Yukon river and of the Klondike river. On Coal creek, a branch of Rock creek, a tributary of the Klondike, a seam occurs in which a tunnel some 400 feet in length has been driven. These workings are situated about 20 miles from Dawson. The seam worked here consists of an upper part of 3 feet of hard lignite, and a lower part of 2 to 3 feet, separated by a layer of clay of about one foot. Outcrops of lignite also occur on Cliff creek, which enters the Yukon about 55 miles below Dawson. Between these two occurrences, other outcrops have been observed at intermediate points, and it has been estimated that this area underlaid by lignite exceeds 200 square miles.

On Cliff creek the lignite is worked very actively by the North American Trading and Transportation Company. The workings are situated on both banks of the creek, $1\frac{1}{2}$ miles from its mouth. The coal is shipped to Dawson for heating purposes and is also used by river steamers. The mine is connected with the shipping wharf by a narrow gauge railway.

COAL.
Analyses.ANALYSES OF CANADIAN COALS.
SYDNEY FIELD, N.S.

Seam of Mine.	Fast or slow cooking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Gravity.	Theor. Evap. Power.	* Analyst.	+ Reference.
		p. c.	p. c.	p. c.	p. c.	p. c.				
Hub seam.....		26.10	65.50	4.50	3.29				d	C
".....		28.62	68.14	3.24	2.29			8.59		D
Block House seam...	S	600	65.57	4.35	2.63	1.292		8.97	a	A
".....		31.94	62.79	5.27	3.76			7.67	a	D
Harbour seam.....	S	.80	67.05	4.30	2.32	1.29		9.19	a	A
".....		34.09	62.92	2.99	2.26			7.76	k	B
".....		30.21	67.73	2.01	.90			9.31	k	D
".....		37.96	54.84	5.60	4.03				d	C
Victoria seam.....	S	.28	67.61	3.50	2.84	1.29		9.27	a	A
".....		38.70	68.40	2.90				8.02	b	D
Sydney main.....	S	3.04	61.50	4.32	1.24	1.30		8.45	c	B
".....		3.13	67.57	5.49				9.25		E
Sydney Colliery.....	S	1.26	60.79	4.12	1.71	1.312		8.33	a	A
".....		33.84	61.54	5.72	3.37			8.49	k	B
McAulay seam, Gowrie mine.		36.25	68.05	5.70	2.34			7.97	p	D
Gowrie Colliery.....	S	.50	66.01	5.36	2.71	1.31		9.05	a	A
Phelan seam, Caledonia Coll.	S	.92	64.02	6.43	1.11	1.33		8.78	a	A
".....		28.03	57.37	9.63				7.88	d	B
".....		33.00	68.05	2.19	1.72				y	C
".....		28.02	68.05	2.95					y	C
Reserve Coll.....		32.00	63.93	2.83	1.33				d	B
".....		37.26	58.39	4.35	2.06			8.02	r	B
".....		36.26		4.35	2.47				r	B
".....		1.00	59.50	6.00					s	B
".....			64.50	6.00					s	B
".....		.52	59.73	6.54	1.25				a	A
".....			64.21	6.54	1.25				a	A
Dominion No. 1 Coll.....		26.13	71.22	2.73	1.10			8.19	y	O

[illegible]

INVERNESS FIELD, N.S.

[illegible]

†REFERENCES.

a Gilpin, E.
b How, H.
c Brown, R.
d Harrington, B. J.
e N. Y. Gas Co.
f N. Y. Steel Co.
g Mason, F. H.
h Brown, R.
i Harrington, B. J.
j N. Y. Gas Co.
k N. Y. Steel Co.
l N. Y. Steel Co.
m N. Y. Steel Co.
n N. Y. Steel Co.
o N. Y. Steel Co.
p N. Y. Steel Co.
q N. Y. Steel Co.
r N. Y. Steel Co.
s N. Y. Steel Co.
t N. Y. Steel Co.
u N. Y. Steel Co.
v N. Y. Steel Co.
w N. Y. Steel Co.
x N. Y. Steel Co.
y N. Y. Steel Co.
z N. Y. Steel Co.

COAL.
Analyses.

COAL.
Analyses.

ANALYSES OF CANADIAN COALS—Continued.

RICHMOND FIELD, N.S.

Seam or Mine.	Fast or slow coking.	Moisture. p.c.	Vol. Matter. p.c.	Fixed Carbon. p.c.	Ash. p.c.	Sulphur. p.c.	Spec. Grav.	Theor. Evap. Power.	*Analyst.	†Reference.
			p.c.	p.c.	p.c.	p.c.			b	A
Sea Coal Bay, 11-foot seam.			25.20	44.70	30.10					A
Little River, 4-foot seam.			30.26	56.40	13.25					A

PICTOU FIELD, N.S.

Main seam, average of 31 analyses (a).	S	23.65	62.61	13.61	.55	1.294	9.13	b	B
" Ford pit.	S	24.28	66.50	7.74	.48	1.31	8.68	c	B
Albion Mines.	S	1.05	63.41	9.35	1.48			d	A
Acadia Coal Co.—McGregor pit, slack.	S	1.50	58.00	13.70	1.73			e	F
" " Ford pit.	S	1.50	54.30	18.30	.73			m	F
Acadia Colliery.	S	2.10	57.57	7.56	.51	1.320		n	B
Drummond Colliery—Top coal.		.72	60.35	9.46	.26	1.309	8.29	d	B
" " Fall coal.		1.56	60.32	7.56	.43	1.328	8.29	d	B
" " 1st bench.		1.80	55.39	10.50	.58	1.327	7.61	d	B
" " 2nd "		1.31	60.31	8.97	1.05	1.343	8.29	d	B
" " 3rd "		1.43	59.89	8.79	.564	1.335	8.27	d	B
" " Coarse bench.		1.68	37.16	31.03		1.765		d	B
Deep seam.	S	.75	68.50	10.41	.945	1.330	9.39	a	A
" " " "	S	1.30	61.65	10.25	.861	1.330		d	B
" " " "		2.54	63.50	8.50	1.69	1.345	9.41	c	B
McGregor seam.		23.50	65.70	11.80		1.334	9.03		B
" " " "		23.30	70.00	6.70		1.301	9.62		B

COAL.
Analyses.*

Intercolonial Mine	S	1.52	29.46	60.19	9.10	1.025	1.330	8.24	A
Montreal and Pictou Mines		4.40	24.96	61.07	9.68			8.39	B
" "		5.47	19.93	68.55	6.05		1.360	9.41	B
McBean seam, east side of East River		1.57	29.29	52.36	16.76				B
" "		2.67	28.65	49.66	19.42				B
" "		2.67	27.20	54.96	15.27				B
" "		1.94	23.95	57.17	16.94				B
McKay seam, north part	S	.86	20.96	64.96	13.24	.85		8.90	A
" "	S	1.62	22.86	68.18	7.84	.53		9.35	A
" "		.90	22.50	65.28	11.32	1.72		8.97	A
" "		None.	29.72	62.28	8.00				B
" "		None.	29.98	62.15	7.87				B
Richardson seam		.76	38.84	55.81	5.09				B
Greener	S	1.22	22.96	65.61	10.21	Trace.		8.99	A
Pottory		.57	19.24	73.76	7.43	.65		9.97	A

CUMBERLAND FIELD, N.S.

Joggins	S	2.50	36.30	56.00	5.00				A
Maacan	S		37.00	59.17	3.53				A
Styles	S	4.06	33.72	55.83	6.40				A
" "	S	3.72	33.24	52.15	10.89				A
Springhill—Main seam, 11 feet—									
Band No. 1	S	.98	30.84	60.73	7.45	.85	1.31	8.33	A
" No. 2	S	.76	32.22	60.91	6.11	.56	1.30	8.40	A
" No. 3	S	1.21	33.81	63.13	1.85	.79	1.28	8.65	A
" No. 4	S	.30	29.19	67.96	2.56	1.21	1.27	9.28	A
" No. 5	S	.63	28.90	65.16	5.31	1.95	1.29	8.92	A
" No. 6	S	.90	34.56	60.59	3.95	.98	1.28	8.32	A
" No. 7	S	1.34	33.64	59.86	5.16	1.40	1.29	8.20	A
" No. 8	S	.56	30.27	60.89	8.28	2.65	1.33	8.35	A
" No. 9	S	.41	28.54	63.63	7.42	2.25	1.32	8.99	A

(a) Average of samples taken every foot across the section of the seam.

MINES SECTION

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COAL.
Analyses.

	S	9.18	30.66	53.31	6.85		1.398	10.84	B
Belly river, 5 miles below Little Bow river.	S	6.50	31.59	54.36	7.55		1.369	11.51	B
coal banks, seam 5 $\frac{1}{2}$.	S	7.02	29.41	57.28	6.29		1.369	11.72	B
St. Mary river, 7 miles above junction with Belly river.	S	7.24	41.45	48.91	2.40				B
Yukon District, 7 miles up Coal creek, seam 12 $\frac{1}{2}$ feet.	F								
COALS.									
Cascade river, $\frac{2}{3}$ miles from confluence with Bow river, seam 20 inches.	S	2.07	15.84	74.35	7.74				B
Cascadia river, semi-anthracite, seam 3 feet 10 inches, $\frac{1}{2}$ mile from C.P.R.	F	1.04	9.15	87.18	2.63				B
Bow river, Coal creek seam 4 $\frac{1}{2}$ feet.	S	4.93	27.22	52.54	15.31		1.400	10.93	B
Bow river Pass seam 4 feet.	S	.71	10.53	81.14	7.57		1.427	14.62	B
Coal creek, Bow river, Sec. 22, Tp. 27, R. 5, west of 5th M.	F	2.79	36.90	53.40	6.91				B
Marsh's Mine, $\frac{1}{4}$ mile south of Bow river at Gap siding, 2 seams, 10 and 12 feet.		.70	11.03	79.78	8.49				B
Little Red Deer river, 11-foot seam: foot-hills at base of main limestone range of Rocky mountains.	F	1.87	13.74	79.55	4.84				B
Little Red Deer river, seam 4 feet.	F	1.52	11.65	81.16	5.67				B
Sheep creek, Sec. 2, Tp. 20, R. 3, west of 5th M., 4-foot seam.	F	3.08	39.37	54.50	3.05				B
Near Moose mountain, Sec. 8, Tp. 23, R. 6, west of 5th M., seam 5 feet.	F	2.74	18.62	75.52	3.12				B
Head waters of Mill and Pincher creeks, Sec. 10, Tp. 5, R. 1, west of 5th M., seam 8 feet.		1.99	20.83	61.87	15.26				B
Old Man river, north fork, 5 feet.	S	1.75	16.85	61.54	19.86		1.530	11.32	B
" " middle fork, 3 feet.	S	3.27	26.41	50.50	19.82		1.432	11.13	B
" " south fork, 3 "	S	2.36	32.07	56.37	9.20		1.311	13.06	B
" " south fork, 9 $\frac{1}{2}$ "	F	1.93	23.23	57.50	17.34				B
Anthracite, Alberta Territory, H. W. McNeil & Co. —									F
1st vein, raw		10	13.09	78.94	7.87				F
" washed		.39	14.82	79.98	4.84				F
2nd vein, raw		.42	15.46	75.07	9.05				F
" washed		.40	6.02	89.40	4.18				F
3rd vein, raw		.08	15.12	76.67	8.13				F
" washed		.07	15.30	79.46	5.17				F

* } See page 51.
+ }

COAL.
Analyses.

ANALYSES OF CANADIAN COALS—Continued.

CROW'S NEST PASS, B.C.

Seam or Mine.	Fast or slow coking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Gravity.	Theor. Evap.	* Analyst.	† Reference.
		p. c.	p. c.	p. c.	p. c.	p. c.				
Marten creek—Peter seam, 14 ft.	S	1.79	25.45	69.14	3.62	.51	1.305	14.99	?	B
" Jubilee seam, 30 ft.	S	1.89	24.88	68.86	4.37	.48	1.309	14.64	?	B
" Four seams, 3, 4, 5 and 6 ft.	S	2.10	44.41	43.63	9.86	.....	.....	.....	?	B
" Two-foot seam.	F	2.12	26.92	43.48	27.48	.....	.....	.....	?	B
" Middle seam, 2½ ft.	F	1.82	24.55	51.22	22.41	.....	.....	.....	?	B
On Elk river seam, 15 feet ....	.....	.....	21.76	68.20	10.04	.....	.....	.....	?	B
Morrissey mine, No. 1—Highest seam worked; 18 ft. thick; dip, N. 21°; strike, E and W; suitable for steam.	.....	.9	22.19	70.99	5.6	.....	.32	14.346	u	G
Morrissey mine, No. 2—Seam, 18 ft.; dip and strike same as above; suitable for steam and household.	.....	.82	11.73	71.5	15.75	.2	.....	12.858	u	G
Coal creek mine, No. 1—Seam, 8 ft.; dip, E. 15°; suit- able for steam and household.	.....	.84	22.38	73.17	3.15	.46	.....	14.935	u	G
" No. 1—Seam, 9 ft.; dip, E. 15°; steam and household.	.....	.92	18.85	64.42	15.65	.16	.....	13.757	u	G
" No. 2—Seam, 6 ft.; dip, E. 15°; suit- able for steam and household.	.....	.84	22.38	73.17	3.15	.46	.....	14.935	u	G
" No. 3—Same seam as above; samples taken one mile apart.	.....	.92	20.63	72.05	6.0	.4	.....	14.284	u	G
" No. 4—750 ft. below No. 1; seam, 22 ft.; dip, E.; 10°.	.....	.96	13.46	61.92	23.5	.16	.....	12.114	u	G
Michel Mine, No. 3—Highest seam worked, 15 to 30 ft.; used for steam and coke.	.....	1.0	20.57	72.00	6.15	.28	.....	14.656	u	G
" No. 4—80 feet below No. 3; 10 to 30 ft.; used for steam and coke.	.....	1.0	18.93	70.13	9.5	.44	.....	13.850	u	G

NICOLA VALLEY.

Nicola river, mouth of Coldwater river.	2.13	27.90	59.08	10.22	u
Coal gully, Iron mountain.	3.35	26.55	59.30	10.30	u

NANAIMO FIELD, B.C.

Wellington mines, Nanaimo	2.75	30.95	59.72	6.58	B
Upper seam, Nanaimo.	38.40		51.45	10.15	B
Newcastle island, Nanaimo	1.57	30.95	58.03	8.63	B
" " " "	35.49		52.57	11.94	B
Esplanade, No. 1 shaft, upper seam.	1.88	33.27	54.67	9.4	G
" " " lower seam	2.86	35.84	54.79	5.5	G
Harewood mine.	1.58	33.84	52.17	11.85	G
Southfield mine, No. 5	2.08	35.78	56.26	5.6	G
Extension seam, bottom vein	1.28	35.28	55.83	7.30	G
" " top vein	1.24	36.49	58.72	8.20	G
Tunnel vein, bottom seam	1.52	35.27	57.04	5.85	G
" " "	1.44	31.40	46.18	20.65	G

COMOX FIELD, B.C.

Union Colliery	1.34	28.11	67.72	2.83	B
" "	1.70	27.17	68.27	2.86	B
Baynes sound mine.	1.18	34.13	48.51	16.18	B
Trent river	.97	25.09	66.42	6.95	B
Beaufort mine, Comox.	29.30		55.75	14.95	B
Union No. 5 Pit upper seam	1.08	29.24	57.03	9.60	G
Hamilton lake.	1.70	22.82	47.72	27.00	G
No. 4 Slope Comox or lower seam	.88	27.34	61.82	8.70	G
No. 5 Pit	1.32	27.62	63.64	6.70	G
No. 6 Pit	1.26	27.33	63.49	6.80	G

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GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc. (CANTAB.), LL.D., F.R.S., I.S.O.

MINERAL RESOURCES OF CANADA

BULLETIN

ON

ASBESTUS

BY

R. W. ELLS, LL.D., F.R.S.C.



OTTAWA

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THE ASBESTUS DEPOSITS OF CANADA.

By R. W. ELLS.

The asbestos deposits of Canada are found in the peculiar rock group known as the serpentines. These rocks occurs in many parts of the Dominion and at widely separated geological horizons, ranging from the oldest crystallines of Ontario and Quebec, which are usually described under the name Archaean, to the Cænozoic of British Columbia.

Occurrence of
asbestos.

In the far east, serpentine has been observed in connection with the limestones of the oldest division in the island of Cape Breton, Nova Scotia, and in the vicinity of St. John, New Brunswick. In Quebec, north of the Ottawa river, similar serpentines are also found in connection with limestone of a like character, as also in eastern Ontario. These limestones belong to what are styled the Grenville and Hastings series. Occasionally masses of dioritic rocks in all these areas are serpentinized to some extent and small veinings of asbestos are found in portions of the rock-mass.

Localities
where found.

Among the eruptive rocks west of Lake Superior, notably at the Lake of the Woods, the occurrence of serpentine has been recorded by Dr. Dawson and by other geologists who have traversed the area, but these occurrences in so far as examined, appear to be practically destitute of asbestos. Further west in British Columbia, Dr. Dawson records the presence of serpentine in the rocks of the Cache Creek series which were regarded by him as of Carboniferous age; while in the Yukon district the same observer mentions the presence of similar serpentines and says that small veins of asbestos, which may have been derived from some of these rock masses, have been found; but the exact locality of the deposits of this mineral are not definitely known. The serpentines of the maritime provinces have not as yet yielded asbestos in economic quantities and the rocks are, so far as known, practically destitute of this mineral.

Serpentine of
the west.

In the province of Quebec the serpentines are of two kinds and belong to two distinct horizons. The oldest are associated with the crystalline limestones of the Grenville series and the mineral is found at a number of widely separated points throughout the area north of the Ottawa

Serpentine of
Quebec.

Alteration
from gabbro.

river. Asbestos frequently occurs in the rock in zones of the serpentine which form the outer part of pyroxenite masses and is usually white in colour. These masses are scattered through the limestone formation, generally in the form of bodies of various sizes, but sometimes as longitudinal bands of the pyroxenite which occur nearly along the lines of the banding of the containing limestone. In the Eastern Townships, where the large workable deposits are located, the serpentine occurs as an alteration product from great masses of olivine diabase which run in an extensively developed, but irregular band, from the Vermont boundary nearly to the extremity of Gaspé peninsula. The alteration of these diabase rocks can readily be observed in the field as well as under the microscope. Portions of the eruptive mass are entirely altered to serpentine, while very often intermediate stages can be observed and the rock is then merely a serpentinized diorite or gabbro. The asbestos veins here occur distributed throughout portions of the serpentine mass, intersecting the rock in all directions, with thicknesses ranging from mere threads up to four and occasionally six inches.

Age of
associated
rocks.

The associated rocks are usually hard, schistose slates and quartzite of the Cambrian series, occasionally intersected by quartz veins, and passing at times into a true mica schist. These are cut by granites and diorites, and the serpentine masses themselves have been invaded by dykes, and sometimes contain large areas, of a whitish granite.

While the development of these serpentines of the Eastern Townships is quite extensive, a close study of their field relations and characteristics soon serves to show that the rock varies greatly in aspect in different areas. Sometimes it assumes a slaty or schistose structure and when this is developed the lines of schistosity conform with those of the surrounding rocks, showing that the same causes of metamorphism have affected both series.

Character
of the
serpentine.

The difference in the character of the serpentines of this eastern belt is apparently to some extent due to the amount of alteration the original diabase rock has undergone. Serpentine is a hydrous silicate of magnesia, but the percentage of water varies greatly in different portions of the rock-mass and when it falls below a certain normal amount the rock itself becomes too hard and dry to produce asbestos veins of proper texture and size for economic working. This hard condition is found in much of the rock composing the serpentine belt; and even in the rich districts of Thetford and Black Lake, where the greatest amount of asbestos is obtained, large masses of the rock are unproductive, apparently from this cause. To one familiar with the peculiarities of asbestos rock, the dry and barren variety can usually be

readily recognized in the field by its colour and its peculiar weathering. It may be here remarked that all the asbestos produced in this field belongs to the variety known as chrysotile.

THE ACTINOLITE DEPOSITS IN ONTARIO.

In some parts of Ontario, notably in the northern portions of the counties of Hastings and Addington, in connection with the granites, gneiss and crystalline limestone of this area, quite extensive bands of a blackish-green hornblende or amphibolite rock are seen. These are often schistose in structure and form part of what is known as the Hastings series. In Hastings county these hornblende rocks occur in ridges running in a direction about north-east and are bounded on both sides by granites. Associated with the schists are bands of slate-conglomerate, holding quartz pebbles, which are drawn out along the planes of schistosity. The width of the hornblende belt is from 250 to 500 feet and in places the rock is soft, green and highly chloritic. The area is affected by faults, and the asbestiform mineral is developed in a number of zones, pockets and irregular vein-like bands of fibrous hornblende or actinolite which sometimes assumes the form of stellar crystals and sometimes occurs as broad platy crystals of tremolite, the mineral differing from chrysotile in being anhydrous.

Mining has been carried on in these deposits for about twenty years, and a large amount of material has been extracted and hauled to the village of Bridgewater, a distance of about eight miles, where it is milled for the extraction of the fibre which is produced in three grades, Nos. 1 and 2 being employed for boiler coverings and No. 3, which is finely ground for wall plaster under the name of asbestal.

Fibrous hornblende or actinolite is found at a number of other places, sometimes with a fibre of from 10 to 12 inches in length in connection with hornblende or tremolitic rocks, but not in sufficient quantities to make these deposits of economic value.

At the mines in the township of Elzevir, where the mining is principally done, the central portion of the hornblende ridges is often serpentinized, though not altered to a true serpentine rock. The asbestiform minerals are not found in this portion apparently, and in this respect the rock differs from the serpentine of the Eastern Townships of Quebec. The principal mines are situated near a road from Bridgewater to Flinton in the eastern part of the township of Elzevir and of the adjacent township of Kaladar on the east. The actinolite deposits vary in thickness from a few inches up to zones several feet

in width, the stellar variety being usually in bands distinct from the longer or tremolitic fibred mineral, though occasionally both forms are found in the same band. At one point near the eastern extremity of the area in Elzevir a shaft has been sunk to a depth of about 30 feet along a line of fault, the underlying rock being a soft chloritic mineral and the upper portion consisting of a thick body of the actinolite. Slickensided surfaces along the line of contact are visible, and occasional crystals of the stellar variety are seen to extend for several inches into the chloritic foot wall, the dip of which is south-east from 65 to 85 degrees. There is evidently a considerable body of the actinolite at this place, but the mining has so far been confined to the outer surfaces of the hornblende ridges.

Mill product.

The percentage of fiberized rock in the mine output is stated to average from 30 to 40, and of this amount, after passing through the mill, about 10 per cent is extracted in the form of fibre for shipment, so that from 100 tons of the mine rock, about $3\frac{1}{2}$ tons of fibre should be obtained. The price of the fibre is stated to be \$20.00 per ton.

Companies working in the area.

Two companies have been operating at this place, viz.; the International Asbestus Co., with head quarters in New York, and a local office at Tweed, and the Joseph James Co. of Actinolite, formerly called Bridgewater. The latter company now uses a mixture of soapstone and talc, ground together and subsequently mixed with a certain proportion of tar to form roofing cement. The mining of the actinolite was first taken up by Mr. James about 1882, the fibre from the ground actinolite being used for the cement.

THE ASBESTUS DEPOSITS OF THE GRENVILLE SERIES, QUEBEC.

The Grenville series.

The rocks of the Grenville series consist of various coloured gneisses, with masses of white quartzite and limestone in the upper portion, which however are often of only local development. Where the quartzite is absent the upper or grey-mica gneiss passes upward into bands of crystalline limestone which, in the lower part, are interstratified with bands of greyish and often rusty gneiss, but become a well-banded pure limestone in the upper portion of the series. These rocks are invaded by masses of granite, diabase, pyroxene, gabbro and anorthosite, which often assume the character of dykes. The distribution of the limestone is frequently irregular, owing in part to the action of the intrusive rocks. With the pyroxene masses are the deposits of mica and apatite, while graphite of the columnar variety, occurs sometimes in veins but generally as disseminated ore, which occurs both in the upper gneiss and in the crystalline limestone.

The serpentine portion of these rocks is found associated with the limestone and is apparently related to pyroxenite, generally near the contact with gabbro or diorite and occasionally with granite. Sometimes the pyroxenite replaces the lower portion of the limestone bands, but it also occurs in places as concretionary masses scattered throughout the limestone itself, forming concentric zones of serpentine surrounding a central portion of hard white pyroxenite, which resembles a white crystalline limestone, but is generally harder and somewhat finer grained. The width of the serpentine zones is sometimes 8 to 10 inches, though in small concretions it is much less, and in these zones the asbestos (which is a chrysotile) is found in small layers, usually following the contour of the outer coat, and ranging in thickness from mere partings to half an inch or sometimes even more. The fibre is usually fine and silky, quite free from the usual impurity of iron grains, which so frequently break the fibre in the veins of the Eastern Townships deposits. Occasionally a number of these small veins unite and form, for short distances, veins of fair size, reaching in places a thickness of from one to two inches, which speedily split up again into the usual small stringers. A similar thickening of veins is also noticed in connection with some of the asbestos in the mines of the Black Lake belt, in eastern Quebec.

Occurrence
of the
serpentine.

Asbestos
veins.

This mode of occurrence of serpentine with asbestos is found at many places in connection with the limestones in the area north of the Ottawa. The deposits occasionally assume a size sufficient to warrant mining, were it not that the irregularity of the deposits, and the necessity of removing such large quantities of barren rock to obtain the fibred mineral have made these attempts, up to the present, unprofitable, and all the asbestos mining locations in this district have been abandoned. Attempts to separate the fibre from the rock by milling have been made and the separation has been successfully accomplished but not at a profit. More recently the serpentinous portions of these deposits with the contained small fibres have been ground fine and used for boiler coverings and asbestos cements, for which purpose the mineral appears to be well adapted, since it is a non-conductor of heat. In much of the material so used, the presence of asbestos veins cannot be recognized with the naked eye, but a large proportion of the output has a slightly fibrous texture which is maintained after the rock is ground to a fine condition.

Character of
output.

Among the many localities where these deposits are seen north of the Ottawa river the following may be mentioned :

Localities for
asbestos.

Near Paugun falls, Gatineau river, township of Denholm, worked at intervals for some years. Two miles from the railway.

Perkins Mills, township of Templeton, eight miles from the Canadian Pacific Railway. Worked quite extensively for several years, now closed.

Lot II, range VIII, Templeton, and lot 16 range V, the last owned by W. A. Allan, on land of Nicholas Orange. Four miles from the Lievre river.

Newton lake, township of Portland. Mined to some extent in 1892.

Côte St. Pierre, La Petite Nation, about 12 miles north of the Canadian Pacific railway at Papineauville. Mined for asbestos some years ago, but better known of late years as yielding the peculiar form known as *Eozoon Canadense*, for some years regarded as a fossil of Laurentian age.

Shores of Gull and Blanche lakes, township of Mulgrave; worked to a small extent some years ago.

Silver Lake township of Wentworth.

Augmentation of Grenville, several miles north of Pointe au Chene on the Canadian Pacific railway.

Township of Wright, about 4 miles west of Wright post office.

Old Chelsea, about one mile and a half west of Chelsea station on the Gatineau Valley railway. Not worked.

The characteristics of the several deposits are stated in the Annual Report of the Geological Survey for 1899, Vol. XII pp. 105-106. Of the Portland West deposit on lot 16, R.V., it is stated that:—

Character of
deposit in
Templeton.

‘The chrysotile occurs in two principal bands, one of which is near the brow of a ridge of limestone with a band of serpentine near the contact with the gneiss, and with a dyke of white granite or pegmatite along the contact. The elevation of this ridge is about sixty feet above the road at its base, and in the serpentine band there are from twenty five to thirty small veins in a space of two to three feet. Most of these are mere threads, but some reach a thickness of half an inch or even a little more, whereas in Templeton, several coalesce to form for a short distance a thicker vein.

The band of limestone is here exposed for a breadth of about 150 yards. A second narrow band of asbestos bearing-rock occurs near the eastern edge of the area which terminates against a mass of red granite-gneiss. In this area, the concretionary-looking masses of pyroxenite are not observed.”

In contrast with the mode of occurrence of the asbestos at this place the deposits found at Perkins mills may be described in an extract taken from the same report.

"The country rock is also a crystalline limestone, but the serpentinized pyroxenite here frequently assumes the shape of concretionary masses, sometimes like rounded boulders, but also in irregularly shaped areas extending downward to a considerable distance. The exposed surface of the masses has often an irregularly oval outline. The masses themselves consist of a core of white pyroxenite, resembling at first sight certain of the limestones but generally harder and finer grained, surrounded by a zone of serpentine, and near the contact with the limestone the small veins of chrysotile occur. In one pit a section is made across one of the pyroxenite masses, which here has the aspect of a dyke, showing it to descend through the limestone for at least twenty feet, with a thickness of a little more than two feet, and along the margin of which the small chrysotile veins are arranged parallel to the walls. Some of the rounded masses of the pyroxenite are detachable from the limestone and this mode of occurrence presents several interesting features. That the pyroxenite is clearly a distinct rock from the limestone is plainly seen at a number of points, and that the chrysotile is confined to the serpentine can also be readily observed. When the limestone is serpentinized the mineral appears in the form of small irregularly distributed spots forming an ophicalcite, but this is distinct from the serpentinized pyroxenite."

Area near
Perkin's
Mills.

Mode of
occurrence.

THE ASBESTUS DEPOSITS OF THE EASTERN TOWNSHIPS, QUEBEC.

The early history of the asbestos industry as developed in eastern Quebec has been given in the reports of the Geological Survey for the years 1886-1887, and in the "Mineral Resources of Quebec, 1888-89. Since the last date, practically nothing has been written by the officers of the department on this subject beyond the annual statements as to output given in the reports of the Mining Section. As the development of the mines in the districts of Thetford, Black Lake and Danville has been carried on continuously since the latter date, and the conditions of working have been greatly changed, the principal object of the present report is to indicate briefly the more important features connected with the recent development of the industry, and to incorporate any new facts which have been observed in an examination of the several mining areas during the past season.

Asbestos of
Eastern
Townships.

The principal economic feature introduced in connection with the serpentine areas of this district since the report for 1888-89, is the development of the deposits of chromic iron, which, as well as the asbestos, is found in connection with the serpentines of the Eastern

Occurrence of
chromic iron.

Townships. Reference to the occurrence of this mineral was made in the reports already quoted, but at that date the known deposits were of small size and of comparatively little importance. Within the last ten years, however, this branch of mining has come largely to the front, and numerous and often extensive occurrences of chromic iron have been discovered, chiefly in the area of barren serpentine to the south of Black lake in the vicinity of Lakes Caribou and Little St. Francis, from which large quantities of the mineral are now being extracted.

Age of
associated
rocks.

In the earlier reports on this subject the relations of the serpentine to the associated slates and other rocks were indicated. As a rule, the rock forms masses in the great series of slates which have been referred to the Sillery portion of the Quebec group, which are now regarded as a part of the Cambrian system. Most of the serpentine masses are so situated, and the rock, as already observed, is undoubtedly an alteration product from an olivine diabase or gabbro which forms important hill-features in this part of the province. The occurrence of pyroxene in the mass is clearly observed, as also in sections under the microscope.

Intrusive
rocks in
serpentine.

The serpentine itself is frequently cut by white granite, sometimes in the form of narrow dykes which are frequently disclosed in the several pits from which the asbestos is mined. These dykes have shattered and otherwise altered the rock in contact. Other masses of granite, both red and grey, form prominent hills in the area between Black lake and Thetford, but these differ in character from the white dykes alluded to. In places a greenish dioritic rock or gabbro also occurs, which forms ridges. A good example of this is seen on the line of the Quebec Central railway about a mile north of Black Lake station, where the western end of a ridge crosses the track. This gabbro is serpentinous, and in places almost passes over into a true serpentine. The alteration, however, as a whole is not complete.

Character
of barren
serpentine.

The character of the serpentine varies considerably in different areas. Some portions are hard and siliceous, weathering reddish-brown, features seen in much of the rock of the townships of Wolfestown, Ireland and Garthby, as well as in a large part of the high ridge south of Black lake. In this hard serpentine, which often weathers to a peculiar tawny orange yellow, asbestos is rarely found and when present occurs as an imperfectly developed fibre, often stiff and harsh and in short and gashy veins. Seamy partings are frequently seen traversing the serpentine, and these, at first sight, would appear to indicate the presence of large veins of asbestos, but on examination the mineral is usually found to be present as mere thread-like partings in the centre of the seams. These

barren seams are sometimes known as "dead veins." The seamy bands are seen in connection with the workable asbestos veins at all the mines, and in these places the asbestos has evidently segregated from the sides of the surrounding rock. There is no apparent reason for the lack of asbestos in some of these, while it is present in others, unless it is due to the less percentage of water in the barren portion of the serpentine.

The asbestos-bearing serpentine, on the other hand, presents quite distinct features. The rock is usually greyish-weathering, and generally a soft greyish-green on fresh fracture. It frequently contains small grains of magnetic or chromic iron disseminated, which in the formation of the asbestos veins also segregate out and become an integral part of the fibre. A serpentine with a hard, brittle and harsh aspect, and a black colour does not promise well for asbestos. In the mining areas there are masses of this rock, as also of the brown-weathering variety, which are comparatively barren, either because the rock originally contained too little water in composition, or because it has been altered in this respect by the presence of granite or diorite masses.

All the rocks in the district from the Vermont boundary northward, have been involved in the great series of folding and disturbance which has affected the greater part of the strata from the Maine boundary to the St. Lawrence river. The direction of this crushing force was distinctly from south-east to north-west, and it included the masses of serpentine as well as the associated schists and slates, by which they are surrounded. The results of this pressure can be well seen in all the serpentine masses throughout the belt. In small areas the rock has assumed a decidedly slaty or schistose structure throughout, with the development of much talcose matter, but in the larger masses of the Thetford and Black Lake belt, while slips and dislocations are quite numerous and a slaty structure has developed in some portions, the great mass of the rock has withstood the shearing strain to a certain extent, so that the rock, as a whole, is much more massive. This shearing and consequent faulting has often affected the value of large veins of asbestos by cutting off an entire face of working and presenting a barren wall for a time. Great slickensided surfaces are seen and the sides of these fissures are often coated with the soft green serpentine resulting from the action of the thrust movement. Along these thrust-planes the serpentine often occurs in broad sheets forming the variety of asbestos known as microlite, of but small commercial value, since it lacks the soft flexible fibre; but portions of it are utilized in the fibreizing mill with the

"Dead veins.

Character
of productive
serpentine.

Alteration
of the
serpentine.

Slaty
structure.

Faults.

other material. Occasionally these slides have involved veins of asbestos which have been crushed along the line of dislocation and drawn them out to a width of some inches. Where the rock is comparatively undisturbed the fibres of the asbestos veins are usually at right angles to the enclosing walls.

Character of
rocks at East
Broughton.

The slaty or schistose structure of the serpentine is well seen in the outcrops which occur near East Broughton, as also on the Bras du Sud-Ouest and the Des Plantes rivers which are branches of the Chaudière. In these areas, the rock is completely shattered in places and highly cleaved, the cleavage of the slaty portions corresponding with that of the adjacent slates. In these outcrops there are numerous veins of asbestos of good quality which have also been distorted, and flattened along the shearing planes. Similar cleaved masses of the serpentine are found to the south-west in the areas of Bolton township, and about the north side of Orford mountain, while around the shores of Brompton lake the rock is associated with heavy masses of gabbro and diabase.

Origin of
asbestos
veins.

The asbestos veins which traverse the serpentine in all directions in the asbestos-bearing portion probably owe their origin to fissures which have been formed in the rock-mass as a result of some one of the several periods of movement. That some of them were formed prior to the final crushing is probable, since occasional veins are found in the crushed condition; the greater part of these veins however are but little disturbed and are still at right angles to the sides of the fissure. The intrusion of the white granite dykes has probably exercised some influence in this direction, since often in the mining, as the dykes are approached, the veins increase in number as if the rock had been opened up by their action. Sometimes masses of granite invade the serpentine and cut off the rock entirely so that the workings have to be abandoned. When a face of good workings has been cut off by the action of faults, good ground is generally found again by driving for a short distance through the barren wall.

Granite
intrusives.

Segregation
veins.

In whatever way these fissures were formed, it is evident that the subsequent filling of the vein-matter was brought about by a process of segregation from the adjacent sides, in the same way as quartz and certain other mineral veins have been formed. In support of this view, it may be said that the central zone of many of the veins, especially of the larger size, shows a distinct comb of iron particles, while the rock walls are leached out, the colour being markedly changed for some inches on both sides, so that the run of the veins can be readily seen around the sides of the pits. In the dryer and harder rock, some of

these veins are almost filled with the iron grains cemented together with asbestos fibres.

Any one familiar with the character of the serpentines of this district can readily distinguish between that which is likely to prove profitable as a source of asbestos and that which is comparatively barren. Thus, in the area between Thetford and Black lake, certain conditions appear to have prevailed by which the serpentinization of the original gabbro mass has reached a high stage of perfection and much of this ground appears to be exceptionally rich in good fibre. Even in masses of the rock which appear to be wanting in true veins, a certain amount of fibre is disseminated, sufficient in quantity to render a large part of the rock profitable for milling purposes. This feature is entirely absent in the harder and dryer looking serpentine. The character of the rock gradually changes as we advance southward from the comparatively low areas adjacent to the Quebec Central railway, and as we ascend the high range of hills in this direction, at the distance of a mile or so, the rock becomes harder and assumes the peculiar orange-yellow aspect of the more siliceous portion. The veins gradually become smaller, though still abundant in many places, to the top of the high ridge south of the government road between the two villages, and there is a marked decrease in the amount of No. I fibre. Further south the serpentine, in so far as examined, is practically barren as regards asbestos; at least no areas regarded as economically productive have yet been discovered in this direction, but pockety deposits of chromic iron frequently occur.

Different kind
of serpentine.

None of the serpentine areas of the southern belt, which includes those found in the townships of Potton, Sutton, Bolton, Orford, Melbourne and Shipton have as yet proved to be of the class regarded as asbestos-bearing, with the exception of a small area in the last-named township, about four miles east of the village of Danville, where a peculiar dome-shaped outcrop of the soft light green rock occurs, which has been mined for some years. The rocks of this belt are frequently associated with soapstone and dolomite, and have a soft talcose character on the slaty surfaces. The asbestos veins when found are soft, gashy and pasty, or stiff and harsh, owing apparently to the lack of contained water in the mineral.

The southern
belt.

To the north-east of the Chaudière river, areas of serpentine are sometimes met with. They differ in character from that found at Thetford and are generally intimately associated with diabase masses. Small veins of asbestos are sometimes seen, but the conditions, as a whole, are not favourable to the occurrence of the mineral in workable quantities.

The
Chaudière
areas.

The
Shickshock
area.

Still further east, in the Shickshock mountain range of the Gaspé peninsula, a considerable area of these rocks occurs. The character of the serpentine here is also unfavourable to the occurrence of asbestos, much of the area being of the hard, siliceous variety. In places it is banded with red and green colours, and though small veins of asbestos are occasionally seen, nothing of importance, so far as yet known, has been found. Small quantities of chromic iron have been observed at several points on the surface of the mountain. The most easterly outcrop of the rock is seen at Mount Serpentine on Ladysteps brook about ten miles west of Gaspé basin, and here also the serpentine is associated with diorite and hornblende rocks, similar to the rock of the Shickshocks. A few small and irregular veins only were noticed at this place.

THE MINES OF THETFORD AND BLACK LAKE.

Mines of
Thetford.

The discovery of asbestos in this area was made during the construction of the Quebec Central railway, which passes directly across the belt of serpentine between Thetford and the village of Coleraine. In this work the rock was laid bare at what is now the Thetford mines, and a number of veins of asbestos were disclosed at the surface. Attention being directed to these, their value was speedily recognized and mining was begun in 1878 by the Boston Asbestos Co, and by Mr. A. Johnston. The King Bros., of Quebec began operations shortly after. The output by the Boston Co. in 1878 was about 50 tons, taken from the Ward property, which is directly along the line of the railway.

The principal mines in this district are situated on a small ridge of serpentine lying a short distance east of the track, and having an elevation of about 90 feet above the railway. On this ridge the properties of three largest companies, known as Kings, the Bell Co., and the Johnston Co. are all located. The Beaver Asbestos Co. lies to the north of the railway on an adjoining lot to the south-west, being on lot 32 Range C, of Coleraine township. The three first mentioned are in the township of Thetford.

Asbestos
producing
areas.

At present the mining of asbestos is practically confined to the belt of serpentine which extends from the Standard Asbestos Co's property (formerly the Anglo-Canadian) at Black lake to Kings mine at Thetford. In addition, two areas are worked at East Broughton and one at Asbestos village, four miles south-east of Danville, in the township of Shipton. Other mines which have been worked at intervals are situated

about two miles north-west of Coleraine station. All the other mines which were opened years ago at different points in the serpentine belt, are at present closed.

The conditions of mining which prevailed prior to 1889, as regards the separation of the fibre have greatly changed. In the early years of the industry, a great amount of so called waste rock, in the form of dumps was allowed to accumulate and greatly hampered the successful working of the pits. All the mining is now carried on by a system of open quarrying, and the different mines are equipped with a modern outfit of cable derricks, by which the removal of the rock is greatly expedited. It was pointed out in 1888 that a large proportion of the dump material could be profitably handled in properly constructed mills, and a great amount of good fibre which it was found unprofitable to separate by the process of hand-cobbing could in this way be saved. The suggestion was speedily acted upon and now all the mines are equipped with milling plants, so that the product below what is known as crude Nos. 1 and 2, which are still hand-cobbed, passes directly through the mill and the short fibre is there separated, the waste going thence to a dump on what is regarded as barren ground to the west of the railway. In this way most of the large rock dumps have been profitably worked over and greater facilities for operating the pits have been secured, while the present method provides a cheap and economical way of treating the lower grades of rock and saving the short fibre. The manufacture of asbestic is not carried on at any of the Thetford mills to any great extent, and when this is done the asbestic is regarded merely as a by-product.

Conditions of mining.

Milling plant.

During a recent examination of the serpentine areas, all the workable deposits were inspected, including those of Thetford, Black Lake, East Broughton, Ireland and Danville, and some new facts of considerable importance were observed. The industry, as a whole, has been almost entirely revolutionized since the date of the last report on the district in 1888-89 and in the following pages these new features are presented, so that the general conditions and status of the industry may be brought down to the present time.

The old method of open quarry work is still maintained at all the mines, as best suited to the economic extraction of the mineral, since practically all the rock is asbestos-bearing, with the exception of occasional hard bands and limited areas of comparatively barren serpentine, due to displacement of rich ground through the agency of faults, and of certain dykes of granite which traverse the serpentine mass and are of more recent age.

Open quarry work.

Present state
of the quarries
at Thetford.

These open pits now reach a depth of 135 to 150 feet, and an examination of the lower benches shows that the rich ground, holding large veins of first class fibre, continues downward without interruption or perceptible decrease. Possibly the general thickness of some of the large-sized veins noted twenty years ago near the upper portion of these pits has somewhat decreased, but otherwise there appears to be but little difference in the value of the serpentine as a producer. This remark applies to all the three mines mentioned as occurring along the Thetford ridge. In the Beaver property, which is situated on the west side of the railway, the development has not proceeded at the same rate as in the others, and from the fact that mining operations have been suspended on this area for some time owing to change in ownership, the principal openings were filled with water and the lower portions of the pits could not be examined. At the old Ward property, adjacent to the Johnston mine, work has not been carried on for some years, but when formerly examined the area showed excellent fibre. At the Beaver mine, where the pit walls were exposed, the conditions are excellent and the value of the property appears to be equal to what was observed in the early days of the working of this area.

In none of these mines was any well defined zone or belt of asbestos veins recognized. They traverse the serpentine in all directions but are affected by faults, along the course of which, slickensided surfaces are common. But little iron oxide is visible except in the form of disseminated grains and in the partings seen in the large veins. No large pockets of chromic iron have been found in the asbestos-bearing rock, those now worked occurring in the areas to the south where asbestos is rarely seen.

Black Lake
mines.

In the group of mines situated in the Black Lake area the conditions are somewhat different. The rock mass forms a high ridge lying from half a mile to a mile south of the railway with a steep face to the north and north-west. The ownership of several of these mines has changed in the last twelve years so that the names as given on the Geological Survey map of the asbestos area in 1888, require revision. Thus the Anglo-Canadian is now known as the Standard Asbestos Co.; the Danville, afterward the United Asbestos Co. is now the Manhattan; the Scottish-Canadian is now the Glasgow and Montreal; and the American Asbestos Co. is now the Union Asbestos Co. In addition to these areas, a mine has been opened by the Johnston Co. of Thetford on the west end of lot 31, range B; and on lot 32 of the same range formerly owned by Mr. A. Murphy and worked to some extent in 1888, a new company, styled the American Asbestos Co. has

recently commenced mining at another point with a very promising outlook. To the south-west the old workings of George Turcot and of Lomas, and Johnston as also the mines started by King Bros. some ten to twelve years ago have since been abandoned. New areas at Black lake.

The workings in this group of mines have been carried on for many years in the high lying areas along the front of the ridge at elevations of 400 to 700 feet above the line of railway at Black Lake station. The serpentine of this portion has never been as productive of large veins as that of the lower series at Thetford, although the veins themselves are abundant and the quality of the fibre is in many places excellent. As a rule it may be said that the rock of these upper areas is less hydrous than that from the lower workings and the mass of the rock does not contain the same amount of fine veins or milling fibre as that from the Thetford areas.

Owing probably to the fact that much of the lower ground near the railway is largely drift-covered while that of the upper shows the bare rock, these low-lying areas were left practically unproved for many years. About four years ago, however, a prospector working for Mr. A. Johnston in this vicinity, uncovered a group of veins of large size and excellent quality on lot 31, range B, and on sinking at this place, the rock was found to resemble in character that from the best mines of the Thetford area, containing many large and fine veins of No. 1 fibre, quite equal to any that had been found in the Thetford district. This discovery has added a new value to all these lower areas adjacent to the railway on the south. New discoveries.
Mr. A. Johnston.

The new area of Messrs Kerr and Slade, now the American Asbestos Co., on lot 32 adjoining lot 31 of Johnston, was discovered accidentally by removing the drift in an excavation, by which several large veins of No. 1 quality were exposed. This new pit is close to the road, leading from Black Lake station to Thetford and about a fourth of a mile from the former place. The present condition of this new pit promises to give good results when it is further developed. The American Asbestos Co. (Kerr and Slade).

The remaining portion of the area between this last property and that of the Beaver Co. near Thetford, which is on the north-east corner of lot 32, range C, Coleraine, has not yet been prospected, with the exception of a small amount of exploratory work in a couple of shallow pits on lot 32 range A, known as the Hayden property. The rock here is a somewhat slaty serpentine of good character but not, where opened, as massive as that of the Thetford areas. A good showing of veins was found and the fibre is of good quality as far as could be ascertained. Ground between Thetford and Black lake.

Dr. James
Reed's areas.

On lots 27, 28 and 29, range A, owned by Dr. James Reed, considerable development has been done within the last ten years. A number of openings or prospects have been made on the face of the serpentine ridge which extends east to a large mass of white and sometimes red granite that forms a conspicuous feature, especially on lot 27. Mining has been carried on to some extent on this lot near the Poudrier road, and some hundreds of tons of good asbestos-bearing rock have been taken out, which carry a number of veins of good size and quality of fibre. Veins with a length of from half an inch to one inch and a half were quite numerous in the upper part of the pit, but in the bottom of the excavation which had a depth of some 30 feet, a number of larger veins, reaching in places a thickness of two and a half inches, of good No. 1 fibre were observed; much of which equals in character that from the best mines of Thetford and Black lake. A considerable amount of crude Nos. 1 and 2 have been cobbled out. There are a number of dykes and masses of white granite in the vicinity, and the quality of the fibre evidently improves as lower workings are reached.

Mining plant. To the north of this, approaching the main granite mass, a number of shallower openings show the presence of thinner veins at the surface. A good, but small mining plant has been erected at this place.

On lot 29, mining is now in progress with a limited force in a pit located in the angle formed by the government road to Thetford and the Poudrier road. The fibre near the surface at this place is not of such good quality, but the veins are numerous and some thousands of tons have been extracted, but not cobbled. A large proportion of this output will make good milling stock. In this connection it may be mentioned that the greater part of the output from the old Black Lake mines is now run through the mill without preliminary cobbing. With the exception of the pits referred to, on this property, but little exploratory work has been done beyond mere surface tests on the slope toward the granite of the higher levels. The greater portion of the areas, being lower and drift-covered, has not yet been tested.

Serpentinized
gabbro ridge.

The ridge of serpentinized gabbro, already alluded to as occurring on the line of railway north of Black Lake station, crosses the railway on lot 26, range VII of Ireland, and extends across the eastern half of lot 32, range B, Coleraine. This rock, while largely serpentinized, cannot be classed as a true serpentine and in portions of the ridge the several phases of the alteration are well displayed. It will be readily seen that in the light of the new discoveries of asbestos, in the areas lying in close proximity to the railway, careful prospecting in this direc-

tion is desirable. Local conditions may, however, favour the occurrence of rich veins at certain points rather than throughout the entire field, but this is a matter for future determination. It has, however, been conclusively proven that the rich ground is not entirely confined to the areas included in the workings of twenty years ago.

East of King Bros. mine in Thetford, the limit of the serpentine ridge has not yet been traced, owing largely to drift deposits and forest growth. By means of test-pits, it has been shown that the serpentine extends in this direction for some distance and that it contains asbestos similar to that found in the pits now worked, and there is apparently no reason why the area of rich ground should not be largely increased in this direction. To the south of the present line of pits, little in the way of prospecting has been attempted and the actual conditions, owing to the drift covering, are not as yet fully known.

Area east of
King Bros.
mine.

On range A, lot 26, Coleraine, some work has also been done and several large pits have been opened. Work has been suspended for some time and the largest of these are now partly filled with water. Indications of veins are quite numerous, but the rock, as a whole, appears to belong to the harder and dryer variety of serpentine, indicating an approach to the comparatively barren belt further to the south-east. A number of short-fibre veins occur in this area, but as a whole, the output must be regarded as milling stock. On the adjacent area, lot 25, but little work of an exploratory kind has been done and the rock here also appears to be largely of the harder variety.

H. W. Johns
and Short
areas.

THE EAST BROUGHTON MINES.

The areas at East Broughton are about 20 miles north-east of those at Thetford. They are small in extent, consisting of two local outcrops of the serpentine situated to the west of the Quebec Central railway, and owing to their limited size are somewhat more highly affected by the alterations which are visible in all the associated rocks of the district, the serpentine being distinctly slaty or schistose.

East Brough-
ton mines.

Three mines are located at this place, known as the old Broughton mine, on lot 14, range VII; the Quebec Asbestos Co. mine on lot 13, same range, and the Broughton Asbestos Co. mine on lot 14, range VIII, near the line of range VII. Work on the first named has been stopped for some time; the others are new areas.

In the old Broughton property (Fraser mine) which was described in the Report for 1888-89, a large amount of work was done some years ago. The serpentine has the slaty structure already mentioned.

The old
Broughton
mine.

The asbestos occurs in small veins on the west portion of the outcrop, but the mining has been, for the most part, confined to a peculiar vein which was developed on the south-east margin of the serpentine close to the contact with the overlying schistose slates. These have a south-east dip at an angle of 65 degrees.

The hanging wall of the vein at this place consists of a soft talcose rock or fine soapstone from 12 to 14 inches thick, and the asbestos vein followed down conformably with the bedding of the overlying rock, reaches a thickness, in places, of 10 to 12 inches. The quality of the fibre was excellent, but the vein was irregular, sometimes splitting up into fine strings disseminated through the serpentine, and at other places uniting to form a good continuous fibre for a considerable distance. It has been worked downward by shafts with drifts for about 100 feet. Portions of the shorter fibred veins appear to be somewhat stiff and harsh in texture. Where the vein attained a large size the fibre was beautifully soft and silky.

The Quebec
Asbestos Co.

At the mine of the Quebec Asbestos Co., on lot 13, range VII, the breadth of the serpentine mass is not more than 150 feet. It is enclosed between greyish schistose altered slates of supposed Cambrian age, in which numerous small gashy veins of white quartz lie along the schist planes. The veins of asbestos are often crushed out along the lines of schistose structure in the serpentine, many of them being short and occurring in the form of sheety partings. Some of the larger veins have a width of two inches or sometimes more, and though somewhat crushed still maintain their fibrous character, so that a certain amount of good No. 1 fibre can be hand-cobbed. The rock, as a whole, is much softer than that of the larger masses at Thetford and the yield of large-sized veins proportionately less. Of the whole output of rock and fibre, it is estimated by Mr. J. Penhale, the manager, that as much as 7 to 7½ per cent can be obtained as fibre from the milling. This is made into three grades, with possibly a fourth saved as a by-product and containing very short fibre, not comparable with the other grades. Great sheets of a ligniform serpentine or asbestos, resembling picrolite, traverse the serpentine, probably along lines of fault. The dip of the cleavage in the serpentine is to the south-east, conforming with that of the cleaved slates.

Broughton
Asbestos Co.

At the Broughton Asbestos mine, which is situated to the south-west of the old Broughton mine and on the extension of the same serpentine area, somewhat similar conditions are seen. The area is larger and the shearing of the rock has not become quite so marked. The enclosing rocks are the usual altered slates and schists of the district with quartz veins.

In the pit, veins of asbestos of large size, sometimes reaching a thickness of from two to three inches, are seen with many of smaller size, so that a good percentage of it can be taken out as Nos. 1 and 2 crude, but a very large proportion of the mine-output goes through the mill, as elsewhere. The mine is well equipped in this direction. The serpentine here also shows many crushed veins along the planes of schistosity. Some of the veins are a clear green; others an amber colour, while near the centre of the pit is a mass of inky-black serpentine, through which are numerous veins of chrysotile of good size and quality, which are also black when freshly mined. A peculiarity of this black mineral, both of the rock and the veins, is that by exposure to the light for a few days the black colour entirely disappears and the rock assumes its usual green tint.

Black
serpentine
and asbestos.

Great bands of the coarse woody-fibred picrolite occur around the sides of the pit, and in one place there is a strong vein of a dark, soft clayey material, probably a decomposed serpentine, with a thickness of from four to six inches, which, after removal, becomes quite hard. Many of the larger veins have the usual partings of chromic iron, and in some of them the mass of the vein is largely composed of this mineral with fibres of the asbestos disseminated.

Picrolite.

The outcrops on the Chaudière river at the Bras du Sud-Ouest, present somewhat different features from those already described. The rock is in places largely a serpentine-breccia, being only partially serpentinized as an alteration apparently from a pyroxenic mass. Occasionally, where the serpentine is better displayed, small veins of impure asbestos are seen, but these are of no economic importance, in so far as developed. The associated rocks are black rusty slates with bands of hard grits and slate conglomerate; and diorite and granite are found in the immediate vicinity.

Outcrops on
the Chaudière
river.

On the DesPlantes river, which is on the north side of the Chaudière, the black and grey altered slates and quartzites are in contact with a dark green slaty serpentine, which is cut by dykes of whitish granite. Some small veins of impure asbestos are seen in this rock, but in so far as could be determined, the deposits are of little value. Both these areas are small in extent and the rock is affected by strong slaty cleavage like that of the Broughton areas.

In the area west of the Quebec Central railway and north east of Thetford mines, several outcrops of serpentine were examined. Among these may be mentioned lots 16, 17 and 18, range IV, Thetford township, where several knolls are found which carry both chromic iron and asbestos, the latter apparently in small quantities. On lot 13,

Areas north
of the Quebec
Central rail-
way.

range V, Broughton, near Robertson station, occurrences of serpentine have been noted, and on the road out to Harvey hill from Broughton station both serpentine and soapstone are seen at several points. Near Kinnears Mills also, in the township of Leeds, several outcrops are found, but these have not yet shown much indications of asbestos, although chromic iron occurs; and in the concession of Ste. Catherine on the road east from St. Sylvester, a mass of the rock was mined some years ago, but nothing of importance was found.

Areas south
of railway.

East of the railway in Thetford township, serpentine is seen on lots 10 and 11, range VII; on lots 14, 15 and 16, range VIII; on lots 14 and 15, range IX; and on lots 5, 7, 9 and 10, range X. The rock at all these places appears to belong rather to the unproductive variety. In Adstock, serpentine is found in several places in that portion adjoining Thetford, but the rock at these points also appears to lack asbestos veins in profitable quantity. The same remark applies to the serpentine in the vicinity of Little Lake St. Francis, though workable deposits of chromic iron are found in this area at a number of points.

THE MINES IN IRELAND AND WOLFESTOWN TOWNSHIPS.

Mines in
Coleraine.

To the west of the railway between Coleraine station and Black lake there is a conspicuous ridge of serpentine, which forms a rugged and well-marked feature in the landscape. The rock is, for the most part, a hard dry siliceous variety, but at several points it has disclosed the presence of asbestos veins, and attempts to mine these have been made by several companies. In the township of Coleraine, on the south-east flank of this great ridge several openings were made in 1886 by the Megantic Mining Company and operations have been carried on at intervals for some years. At this place several large veins were disclosed, but these were not persistent, the greater portion of the mineral being confined to zones of small veins which interlaced the rock and which could only be extracted by crushing the matrix in mills, as they were too small for hand-cobbing. On the extreme north-west side of the ridge on lots 24 and 25, range III, of Ireland, another series of these veins was opened up by King Bros. of Thetford. The rock here presents a roughly bedded appearance with a dip to the north-west of 35 to 40 degrees, in which the fibre was also found in zones, the veins ranging from a quarter of an inch to one inch in thickness, and occurring throughout a working face of six to eight feet. Occasionally even larger veins are found, but the rock between the zones is of the hard unproductive variety, and the output is chiefly of value as milling stock. During the working,

Ireland
township.

King Bros.
mines.

small amounts of crude Nos. 1 and 2 were taken out, and an output amounting to some 500 tons was extracted and hauled a distance of five miles to Coleraine station. The great bulk of the ridge between this area and the shores of Black lake is apparently of the unproductive variety, but on lot 26, range III, there is a knoll of serpentine, on the surface of which there is a showing of veins intersecting the rock, but generally of short character, in which the fibres range up to a length of one inch. Around the sides of Silver mountain, which is the prominent peak west of the lake, small veins are also disclosed, but the district, as a whole, does not appear to be very promising and no mining has yet been attempted. Chromic iron of high grade, is found at several points in this area, but the deposits have not yet been proved as to their actual extent.

Country north
of Black lake.

In the township of Wolfestown, on lots 23 and 24, range II, are located the old Belmina mines. These were worked to some extent in 1886, and a number of veins were disclosed, some of which promised fair returns. The rock is generally of the hard variety, and chromic iron in the shape of pockets occurs, but the grade is rather low, in so far as examined. These mines have been described in the Report for 1886. Furthur to the south-west, around the shores of Breeches lake in Garthby and on Lake Nicolet in Ham township, serpentine is also found. At the former locality, asbestus seems to be practically absent, but at the latter place veins are met with, and a considerable amount of the variety of asbestus known as picrolite occurs. No mining-of any consequence has been attempted at these localities.

Belmina
mines.

Ham and
Garthby.

In the south-west portion of the serpentine belt, practically the only mines worked are situated at the north end of Brompton lake. The serpentine of this district is associated with masses of diabase and granite, and differs in character from the purer serpentines of the Thetford and Black Lake area. As a rule, it is harder and darker-coloured, but in places it becomes talcose in aspect. Some of the contained veins are soft and without a true fibrous character; others are harsh, stiff and lack elasticity. The rock often weathers a tawny yellow, like that which elsewhere carries chromic iron. A considerable amount of development has been done at the Brompton mine, but at present the work has been discontinued. The area has never been a producer to any large extent.

Areas near
Broughton
lake.

The small openings in the serpentine outcrops west of Memphremagog lake have never yielded merchantable asbestus. The rock is sometimes soft and talcose, often slaty, and the fibre occurs in small and gashy veins of but little value. This area contains much eruptive rock, in

Areas west of
Memphrema-
gog lake.

the form of diabase with some granite, and large areas of siliceous magnesite and dolomite. The general indications are unfavourable to the presence of asbestos in workable quantities in this southern district.

The Danville
area.

The mine near Danville occurs in a detached mass of good serpentine of small size. It was opened in 1885-86 and at first showed a number of good-sized veins of fine quality, from which a large percentage of Nos. 1 and 2 crude was obtained. The area is much affected by faults and the large veins were apparently cut off to some extent. At present the output is confined principally to milling stock, but the general character of the rock is excellent, small veins, up to half an inch and over being abundant, while much of the rock-mass contains a great deal of disseminated short fibre asbestos which is easily separated in the milling process. A small amount of good No. 1 crude is still taken out and about 10 per cent of No. 2 by hand-cobbing. The manager, Mr. Pearson, says about 75 to 80 per cent of the rock quarried now goes through the mill, producing an excellent quality of fibre which is separated into three grades as elsewhere. In the last two years 10,000 tons of this fibre have been produced. As a milling proposition, this mine is one of the best in the serpentine areas. The asbestic, of which a certain amount is produced, as a fourth grade, is merely a by-product for which a good market is readily obtained at remunerative prices. The mill is well equipped with a complete milling plant, and the mine is connected by a branch railway four miles in length with the Grand Trunk line at Danville station. The main pit has now reached a depth of about 150 feet and is furnished with a cable-derrick. Dykes of the white granite traverse the sides of the pit and the veins are numerous in all directions, though generally of small size.

GENERAL CONDITIONS OF THE INDUSTRY.

Present
condition of
mining plant.

Within the last twelve years the general aspect of the mining towns of Black Lake and Thetford has greatly changed. At all the mines which are still carried on by the system of open quarry work, cable-derricks, steam trams and an elaborate system of milling plant for the separation of fibre have been installed, so that the lower grades of rock which formerly were partly treated by hand-cobbing and produced in this way a certain amount of No. 3 grade fibre, are readily and economically handled. The grades Nos. 1 and 2 are still extracted by hand-cobbing, as crude. The villages are supplied with good water, brought in by gravity from lakes several miles distant; streets are well laid out and electric lighting has been installed.

The milling process is largely automatic throughout. After the rock suitable for hand cobbing is extracted, the bulk of the output is run to the mill by steam trams, and the rough material passes at once to a Blake crusher, generally of two dimensions, where it is sized for the rolls. In the King Bros' mills these are corrugated, and the rock from the crusher goes directly through the rolls, from which it passes to a series of cyclones that reduce the rock to powder and separate the contained fibre. Exhausts are provided by which the greater part of this is removed and the material from the cyclone passes on to a set of shaking screens of different sized mesh by which the fiberized material is separated ready for bagging. Boys are stationed at points to regulate the supply of the material along the conveying belts. The bottom of the mine holds a considerable amount of broken fibre, generally wet and dirty and this before going through the mill is put through a drying cylinder set at an angle of about 5 degrees and revolving slowly, by which the moisture is readily extracted. At present the motive power in all the mills is steam.

The milling process.

While the general principle in all these mills is practically the same, scarcely two are built on precisely the same plan. In some, the rolls are discarded, and other points of difference are seen depending upon the conditions at different mines. The extraction of the fibre is successfully accomplished at all the mines, and a large amount of the rock output which formerly would have gone to the dump as waste material is now profitably utilized. At the present time, at Black Lake, with the exception of Mr. Johnston's new mine, and that of the American Asbestos Co., which is still in the development stage, the greater portion of the output in this district is sent to the mill and the production of crude asbestos which at one time formed an important part of the output at this place has in consequence largely fallen off.

PRODUCTION.

The production of asbestos has steadily increased since the commencement of the industry in the province of Quebec. Thus, from an output in 1880 of 380 tons, valued at \$24,700 it reached in 1901, a total, including asbestic, of 40,217 tons, worth \$1,259,759.

Production of asbestos.

In 1896 the manufacture of asbestic was commenced. This is largely a finely ground serpentine in which there is a small amount of very fine fibre disseminated, and the resulting product is specially adapted for fine plaster for walls and interior decoration. It is usually made as a by-product from the residue after separating the fibre in the

